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PRODUCTION OF EXPLOSIVES IN THE UNITED STATES

DURING THE CALENDAR YEAR 1920

WITH NOTES ON MINE ACCIDENTS DUE TO EXPLOSIVES

BY

WILLIAM W. ADAMS

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PRODUCTION AND DISTRIBUTION OF EXPLOSIVES IN THE UNITED STATES DURING THE CALENDAR YEAR 1920.

By William W. Adams.

INTRODUCTION.

The production[1] of explosives in the United States during the calendar year 1920 showed a marked recovery from the slump in 1919. As reported to the Bureau of Mines by the manufacturers, the production (excluding exports) was 537,954,750 pounds, an increase of 120,320,280 pounds, or about 29 per cent, as compared with the preceding year. Of this amount 254,879,825 pounds, or 47 per cent, was black blasting powder; 229,112,084 pounds, or 43 per cent, was high explosives other than permissible explosives; and 53,962,841 pounds, or 10 per cent, was permissible explosives. As compared with the year 1919, there was an increase of 41 per cent in the production of black powder, 15 per cent in "high" explosives, and 39 per cent in explosives classified as "permissibles."

The quantity of permissible explosives sold in 1920 has never before been equaled, and the sales of black powder were, with one exception (1917), likewise larger than for any previous year. The quantity of "high" explosives sold in 1920, while considerably above that for 1919 and 1918, was still below normal.

The reports show that practically all classes of consumers used larger quantities of explosives in 1920 than in 1919. The mining industry consumed 75.1 per cent of all explosives in 1920 as compared with 75.3 per cent in 1919. The principal increase was in coal mining, an industry that ordinarily consumes over 80 per cent each of all black powder and permissible explosives and about 15 per cent of high explosives, or over half of these three classes combined.

CLASSIFICATION OF EXPLOSIVES.

The figures tabulated herein are classified as follows:

1. *Black blasting powder.*—All black powder with sodium or potassium nitrate as a constituent is here classified as black blasting powder.

2. *High explosives.*—Dynamite and all other high explosives of various trade names and compositions, except permissible explosives, are put in this class.

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[1] In this publication the production of explosives means the total sales during the year as reported by manufacturers.

3. *Permissible explosives.*—In this class are included ammonium nitrate explosives, hydrated explosives, organic nitrate explosives, and certain nitroglycerin explosives containing an excess of free water or carbon. All permissible explosives have passed certain tests of the Bureau of Mines and are not to be regarded as permissible unless used in the manner specified by the bureau.[1]

ACKNOWLEDGMENTS.

The compilation of this report is made possible by the hearty cooperation of explosives manufacturers and that of Mr. C. Stewart Comeaux, secretary of the Institute of Makers of Explosives. For this cooperation the Bureau of Mines expresses its deep appreciation. The author acknowledges the assistance rendered by Miss L. S Gerry in compiling the statistical tables herein presented.

SCOPE OF STATISTICS.

The data for 1920 presented in this publication are based upon the reports of sales of explosives by 27 manufacturers. Of these companies, 20 reported sales of black blasting powder; 20 of high explosives; and 13 of permissible explosives. Some of the manufacturers operated more than one plant, so that the number of companies does not indicate the number of operating plants. Several companies reported their plants as idle during the year.

Reports of manufacturers of ammunition and fireworks are not included in this publication, because the majority of such companies purchase their explosives from the manufacturers whose production has been included in the tables herein presented. Nor does this publication include the production of nitroglycerin, except in so far as nitroglycerin is used in the manufacture of other explosives.

PRODUCTION AND DISTRIBUTION OF EXPLOSIVES.

Table 1 shows the quantity of each class of explosives used in each State during the calendar years 1919 and 1920. A comparison of the figures for the two years discloses the fact that the increase in the consumption of explosives in 1920 was not confined to any one section or group of States but was well distributed throughout the country.

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[1] Hall, Clarence, Snelling, W. O., and Howell, S. P., Investigations of explosives used in coal mines with a chapter on the natural gas used at Pittsburgh, by G. A. Burrell, and an introduction by C. E. Munroe: Bull. 15, Bureau of Mines, 1912, 197 pp. Hall, Clarence, and Howell, S. P., Tests of permissible explosives: Bull. 66, Bureau of Mines, 1913, 313 pp.

TABLE 1.—*Amount of explosives (excluding exports) manufactured in the United States and used in the various States during the calendar years 1919 and 1920.*

State.	1919			1920		
	Black blasting powder.	High explosives other than permissible.	Permissible explosives.	Black blasting powder.	High explosives other than permissible.	Permissible explosives.
	Kegs.	*Pounds.*	*Pounds.*	*Kegs.*	*Pounds.*	*Pounds.*
Alabama	137,390	5,069,614	2,983,250	140,259	7,220,796	4,068,974
Alaska	1,730	3,145,950	1,000	193	3,360,700	4,300
Arizona	27,900	10,067,700	3,650	17,154	10,182,462	294,950
Arkansas	70,027	1,530,937	98,805	117,814	2,740,716	208,556
California	69,375	10,962,816	....	65,547	11,959,043	1,095
Colorado	82,246	4,290,280	620,360	107,882	4,400,425	966,875
Connecticut	748	472,967	....	667	555,900	150
Delaware	23	58,171	....	63	52,300	....
Florida	1,225	1,190,925	10,400	3,302	2,061,735	157,600
Georgia	10,011	650,384	51,850	7,500	916,243	80,650
Idaho	14,409	3,029,425	3,000	19,775	3,955,905	550
Illinois	1,225,049	3,939,370	2,284,240	1,952,091	5,154,102	3,398,167
Indiana	725,912	1,859,220	301,925	1,175,434	2,418,722	618,270
Iowa	250,314	1,665,768	20,500	339,502	2,101,812	64,820
Kansas	346,528	5,293,369	135,405	377,596	6,489,070	75,990
Kentucky	493,417	1,742,723	1,151,774	845,420	2,274,548	1,416,522
Louisiana	88	603,131	136,327	533	822,403	178,150
Maine	1,663	450,376	....	2,516	656,825	....
Maryland and District of Columbia	28,625	1,148,911	65,700	55,042	1,458,006	263,900
Massachusetts	3,090	557,275	100	6,223	574,867	....
Michigan	7,546	22,703,853	6,500	20,665	22,891,830	7,750
Minnesota	143,714	9,664,132	200	182,922	10,644,333	5,600
Mississippi	4,220	388,022	30,600	1,431	899,185	91,390
Missouri	136,069	6,432,898	251,290	225,410	7,565,792	219,375
Montana	83,175	5,461,872	43,670	131,506	5,198,495	38,200
Nebraska	2,252	158,075	500	3,260	270,825	3,200
Nevada	21,126	3,240,840	1,300	40,827	3,363,075	3,000
New Hampshire	503	144,499	....	503	224,275	....
New Jersey	2,179	2,338,695	9,675	2,582	2,481,757	3,275
New Mexico	8,066	2,870,410	522,900	23,596	3,010,360	720,450
New York	12,913	6,933,533	544,025	16,294	7,444,671	545,340
North Carolina	9,632	1,479,451	2,250	17,168	1,929,759	8,750
North Dakota	21,507	270,025	200	33,487	381,190	400
Ohio	385,331	5,447,754	124,784	719,549	6,608,435	237,737
Oklahoma	104,391	9,426,729	914,856	198,867	10,274,443	1,052,675
Oregon	32,453	3,421,502	550	36,444	4,543,277	3,200
Pennsylvania	1,821,721	33,386,218	18,760,337	1,928,141	39,090,227	23,562,772
Rhode Island	125	97,125	....	290	88,800	....
South Carolina	794	266,931	100	1,225	434,212	500
South Dakota	2,760	772,654	....	1,553	958,025	10,500
Tennessee	117,095	2,807,299	304,050	196,685	2,858,252	506,370
Texas	50,976	1,355,414	109,165	61,638	1,919,840	230,963
Utah	24,538	3,573,638	2,142,760	27,729	3,182,100	3,275,430
Vermont	2,147	181,025	200	5,135	367,125	....
Virginia	89,035	2,319,029	381,776	134,182	2,944,654	819,500
Washington	28,131	5,461,938	484,750	53,173	7,987,650	879,150
West Virginia	514,969	3,454,319	6,040,388	737,538	5,331,843	9,402,645
Wisconsin	3,007	6,077,271	3,000	2,638	6,558,825	2,100
Wyoming	100,297	404,125	306,720	156,242	502,250	533,050
Total	[a]7,220,442 [b]180,511,050	198,268,588	38,854,832	10,195,193 254,879,825	229,112,084	53,962,841 ....
Grand total (pounds)		417,634,470			537,954,750	

[a] Kegs of 25 pounds each.

[b] Pounds.

BLACK BLASTING POWDER.

A larger quantity of black blasting powder was used during 1920 than in any previous year for which figures are available, except the year 1917. The total sales were 10,195,193 kegs (254,879,825 pounds), an increase of 2,974,751 kegs, or 41 per cent, over 1919, but 889,548 kegs below the amount sold in 1917.

Of the total production in 1920, 8,790,505 kegs (86.2 per cent) was used at coal mines; 347,223 kegs (3.4 per cent) at other mines; 196,172 kegs (1.9 per cent) for railway and other construction work; and 861,293 kegs (8.5 per cent) for miscellaneous purposes.

As compared with 1919, the amount of black powder used for coal mining showed an increase of approximately 2,600,000 kegs, or about 43 per cent. The consumption at coal mines was, in fact, with one exception (1917), larger than for any preceding year. Other mining showed an increase of 95,089 kegs (38 per cent) as compared with 1919, and the consumption was, as at coal mines, larger than that for any other year except 1917. A low level was reached in the amount of black powder used for railway and other construction work, the consumption being 196,172 kegs, or 8,025 kegs below the figure for 1919, and less than one-third as much as the sales reported for 1913. A high mark was reached in the amount of black powder used for miscellaneous purposes, the total sales reported being 861,293 kegs, an increase of 236,787 kegs, or 38 per cent, more than in 1919. (Tables 2, 11, and 12.)

HIGH EXPLOSIVES.

The total quantity of high explosives (other than permissibles) used for all purposes in 1920 was 229,112,084 pounds, an increase of more than 30,000,000 pounds, or about 15 per cent, over the previous year. The production was also considerably above that for 1918 and 1914, but was much below that for other years. Of the entire production in 1920, 37,273,255 pounds, or 16.3 per cent, was used at coal mines, while other kinds of mining consumed 89,132,316 pounds, or 38.9 per cent of the total. Railway and other construction work used 15,052,608 pounds, representing 6.6 per cent of the entire production, and miscellaneous purposes consumed over 87,000,000 pounds, or 38.2 per cent.

As compared with 1919, there was an increase of 7,656,872 pounds of high explosives used at coal mines, a decrease of 622,472 pounds for other mining, an increase of 2,292,985 pounds for railway and other construction work, and an increase of 21,516,111 pounds for miscellaneous purposes.

The consumption of high explosives at coal mines in 1920 exceeded that for any previous year. Miscellaneous purposes used a larger quantity than for any year since 1913. The amount used at mines other than coal mines was practically the same as in 1919 and 1912, but much below the four years 1915 to 1918, inclusive. Railroad and other construction work used a larger quantity of high explosives in 1920 than in either 1919 or 1918, but less than in 1917 and years prior thereto. (Tables 3, 11, and 12.)

PERMISSIBLE EXPLOSIVES.

Sales of permissible explosives in 1920 reached a record-breaking figure. The quantity reported was 53,962,841 pounds, an increase of more than 15,000,000 pounds, or 39 per cent, as compared with 1919, and nearly double the sales reported for 1915.

Of the total sales of permissibles in 1920, the mining industry consumed 90.7 per cent, as compared with 90.9 per cent in 1919. Coal mining consumed 45,222,130 pounds (83.8 per cent) while other mining used 3,750,585 pounds (6.9 per cent). Railroad and other construction work used only 266,505 pounds, or one-half of 1 per cent. Miscellaneous purposes used 4,723,621 pounds, or 8.8 per cent of the total.

The quantity of permissibles used in coal mining was more than double the quantity used in any year prior to 1916. The increase over 1919 was more than 12,000,000 pounds, or 38 per cent. Other mining showed an increase of 1,252,453 pounds, or about 50 per cent, as compared with 1919, but the amount used was still much less than for earlier years. The quantity of permissibles used for railway and other construction work has always been relatively insignificant, but the sales reported for 1920 (266,505 pounds) were 83,152 pounds above those for 1919 and, at the same time, larger than for any other year since 1914. The increase in consumption of permissibles for all other purposes was 1,390,470, as compared with 1919. The total quantity so used (4,723,621 pounds) was also larger than for any previous year. (Tables 4, 11, and 12.)

TABLE 2.—*Amount of black blasting powder used in the United States during 1919 and 1920, classified by use.*

[Kegs of 25 pounds each.]

Groups of States.	Black blasting powder, 1919.				Black blasting powder, 1920.			
	Coal mining.	Other mining.	Railway and other construction work.	All other purposes.	Coal mining.	Other mining.	Railway and other construction work.	All other purposes.
	Kegs.	*Kegs.*	*Kegs.*	*Kegs.*	*Kegs.*	*Kegs.*	*Kegs.*	*Kegs.*
Group 1. Maine, Massachusetts, New Hampshire, Rhode Island, and Vermont			44	7,484			33	14,634
Group 2. Connecticut, New Jersey, and New York		1,927	233	13,680		950	146	18,447
Group 3. Delaware, District of Columbia, Maryland, and Virginia	103,616	1,526	1,828	10,713	174,504	826	3,112	10,845
Pennsylvania	1,622,434	12,880	7,663	178,744	1,695,702	7,892	4,057	220,490
West Virginia	476,552	2,465	7,448	28,504	662,491	1,840	17,014	56,193
Group 4. Florida, Georgia, North Carolina, and South Carolina	1,770	2,621	8,294	8,977	2,101	5,178	9,408	12,508
Group 5. Indiana and Kentucky	1,149,023	7,800	5,498	57,008	1,912,365	6,569	9,883	92,037
Illinois	1,163,311	4,831	742	56,165	1,874,878	3,928	708	72,577
Ohio	345,594	9,676	1,031	29,030	662,374	10,740	198	46,237
Group 6. Alabama, Mississippi, and Tennessee	213,523	7,998	15,378	21,806	284,872	18,740	11,073	23,690
Group 7. Michigan, Minnesota, and Wisconsin	5,259	143,750	762	4,496	13,777	186,282	1,373	4,793
Group 8. Iowa, Kansas, Missouri, and Nebraska	652,243	9,190	5,504	68,226	868,505	11,983	10,167	55,113
Group 9. Arkansas, Louisiana, Oklahoma, and Texas	186,356	1,625	14,976	22,525	317,775	3,811	22,674	34,592
Group 10. Montana, North Dakota, South Dakota, and Wyoming	135,152	11,832	5,024	55,731	214,562	18,531	5,523	84,172
Group 11. Colorado, New Mexico, and Utah	70,947	4,010	16,802	23,091	80,095	26,800	14,258	38,054
Group 12. Alaska, Idaho, Oregon, and Washington	13,825	2,337	38,153	22,408	26,504	1,733	49,514	31,834
Group 13. Arizona, California, and Nevada		27,666	74,817	15,918		41,420	37,031	45,077
Total (kegs)	6,139,605	252,134	204,197	624,506	8,790,505	347,223	196,172	861,293
Grand total (kegs)	**7,220,442**				**10,195,193**			

TABLE 3.—*Amount of high explosives used in the United States during 1919 and 1920, classified by use.*

Groups of States.	High explosives other than permissible explosives, 1919.				High explosives other than permissible explosives, 1920.			
	Coal mining.	Other mining.	Railway and other construction work.	All other purposes.	Coal mining.	Other mining.	Railway and other construction work.	All other purposes.
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
Group 1. Maine, Massachusetts, New Hampshire, Rhode Island, and Vermont		60,825	167,074	1,202,401		52,400	201,229	1,658,263
Group 2. Connecticut, New Jersey, and New York		4,590,189	853,659	4,301,347		4,370,087	1,065,442	5,046,799
Group 3. Delaware, District of Columbia, Maryland, and Virginia	496,313	415,700	278,246	2,335,852	938,323	335,900	367,750	2,812,987
Pennsylvania	20,238,531	434,857	670,966	12,041,864	22,822,640	272,821	604,359	15,390,407
West Virginia	1,013,594	17,750	472,982	1,949,993	1,631,477	48,800	1,054,378	2,597,188
Group 4. Florida, Georgia, North Carolina, and South Carolina	2,400	662,393	650,966	2,271,932	52,700	594,147	998,803	3,696,298
Group 5. Indiana and Kentucky	785,207	193,555	487,339	2,135,842	1,231,080	220,576	475,418	2,766,196
Illinois	460,494	1,384,725	160,147	1,934,004	706,240	1,784,325	189,434	2,474,103
Ohio	613,189	218,400	311,852	4,304,313	861,417	210,100	160,209	5,376,709
Group 6. Albama, Mississippi, and Tennessee	1,413,175	4,224,359	876,998	1,750,403	2,494,742	4,880,177	826,598	2,776,716
Group 7. Michigan, Minnesota, and Wisconsin	110,700	30,235,578	354,589	7,744,389	96,600	28,259,090	458,360	11,280,938
Group 8. Iowa, Kansas, Missouri, and Nebraska	3,159,155	6,815,910	525,640	3,049,405	4,066,111	6,963,250	816,125	4,582,013
Group 9. Arkansas, Louisiana, Oklahoma, and Texas	483,805	8,751,850	788,133	2,892,423	712,720	9,764,128	1,327,608	3,952,946
Group 10. Montana, North Dakota, South Dakota, and Wyoming	323,935	5,737,175	51,920	795,646	386,889	5,535,555	103,905	1,013,611
Group 11. Colorado, New Mexico, and Utah	272,235	6,640,958	118,910	3,702,225	460,120	6,079,430	129,750	3,923,585
Group 12. Alaska, Idaho, Oregon, and Washington	243,650	4,699,050	2,407,420	7,708,695	812,196	5,375,790	3,636,535	9,823,011
Group 13. Arizona, California, and Nevada		14,671,514	3,582,782	6,017,060		14,385,740	2,636,705	8,482,135
Total (pounds)	29,616,383	89,754,788	12,759,623	66,137,794	37,273,255	89,132,316	15,052,608	87,653,905
Grand total (pounds)	**198,268,588**				**229,112,084**			

TABLE 4.—*Amount of permissible explosives used in the United States during 1919 and 1920, classified by use.*

Groups of States.	Permissible explosives, 1919.				Permissible explosives, 1920.			
	Coal mining.	Other mining.	Railway and other construction work.	All other purposes.	Coal mining.	Other mining.	Railway and other construction work.	All other purposes.
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
Group 1. Maine, Massachusetts, New Hampshire, Rhode Island, and Vermont	....	....	....	300	....	....	....	....
Group 2. Connecticut, New Jersey, and New York	....	543,000	550	10,150	....	502,640	....	46,125
Group 3. Delaware, District of Columbia, Maryland, and Virginia	333,176	27,350	1,300	85,650	851,350	83,500	20,250	128,300
Pennsylvania	17,527,997	2,200	950	1,229,190	21,772,959	13,700	23,267	1,752,846
West Virginia	5,343,491	38,200	37,135	621,562	8,382,184	55,100	88,111	877,250
Group 4. Florida, Georgia, North Carolina, and South Carolina	50	600	....	63,950	50	143,000	....	104,450
Group 5. Indiana and Kentucky	1,389,949	13,550	3,500	46,700	1,819,329	30,675	24,288	160,500
Illinois	2,257,815	18,050	300	8,075	3,366,727	17,425	150	13,865
Ohio	1,350	....	....	123,434	41,366	2,000	....	194,371
Group 6. Alabama, Mississippi, and Tennessee	3,104,660	29,767	51,028	132,445	4,293,934	233,760	17,000	122,040
Group 7. Michigan, Minnesota, and Wisconsin	....	3,100	....	6,600	....	6,300	....	9,150
Group 8. Iowa, Kansas, Missouri, and Nebraska	48,970	100,700	5,650	252,375	63,680	76,320	2,400	220,985
Group 9. Arkansas, Louisiana, Oklahoma, and Texas	593,968	382,045	3,790	279,350	1,123,491	121,205	9,614	416,034
Group 10. Montana, North Dakota, South Dakota, and Wyoming	252,020	29,470	....	69,100	152,150	144,400	....	285,600
Group 11. Colorado, New Mexico, and Utah	1,630,750	1,252,500	59,150	343,620	2,592,210	2,075,200	51,075	244,270
Group 12. Alaska, Idaho, Oregon, and Washington	356,000	52,650	20,000	60,650	762,350	15,850	30,150	78,850
Group 13. Arizona, California, and Nevada	....	4,950	....	....	350	229,510	200	68,985
Total (pounds)	32,840,196	2,498,132	183,353	3,333,151	45,222,130	3,750,585	266,505	4,723,621
Grand total (pounds)	**38,854,832**				**53,962,841**			

EXPLOSIVES IN COAL MINING.

The mining industry is by far the largest consumer of explosives in the United States. The quantity thus used is generally about 75 per cent of the total production of all classes of explosives.

Coal mining normally consumes between 80 and 85 per cent of all black powder and permissible explosives used in this country, and between 8 and 16 per cent of other high explosives. Other mining and quarrying operations (excluding coal mines and oil and gas wells) consume from 40 to 50 per cent of all high explosives other than permissibles, 6 to 17 per cent of permissible explosives, and 3 to 4 per cent of black powder. It will thus be seen that most of the explosives used in mining operations are used at coal mines. (Tables 11 and 12.)

It is interesting to note the relative increase or decrease in the consumption of each of these three classes of explosives at coal mines in connection with the production of any given quantity of coal. Comparative figures since 1912 are given in Table 5. They show a most gratifying increase in the use of permissibles. It may be noted that for every thousand tons of coal produced the relative amount of permissibles used, as compared with other explosives, has more than doubled since 1912; black powder has remained practically stationary or slightly decreased, while high explosives have increased about 50 per cent.

Tables 5, 6 and 7 show, for the different coal fields and regions, the annual production of coal and the corresponding quantities of each class of explosives sold for use in coal-mining operations. It will be noted that in 1902 only 11,300 pounds of short-flame or "safety" explosives were used in coal mining, whereas in 1920 the quantity of permissible explosives so used was 45,222,130 pounds. In a parallel column is also shown the annual production of coal in the United States.

The quantity of permissible explosives used in the United States is larger than that of the corresponding explosives used in a number of foreign countries. In 1912 it represented about 5 per cent of the total quantity of explosives produced in this country, and in 1920 it was 10.03 per cent. The total amount of explosives used for the production of coal in 1920 was 302,258,010 pounds, of which 15 per cent was of the permissible class. (Tables 4, 5, 6, 7, 11, and 12.)

TABLE 5.—*Yearly sales of explosives to coal mines compared with yearly production of coal.*

Year.	Production of coal (short tons).	Pounds of explosives sold to coal mines.			Pounds of explosives used per 1,000 tons of coal mined.[a]			
		Permissible explosives.	High explosives.	Black powder.	Permissible explosives.	High explosives.	Black powder.	Total.
1901	293, 299, 816	....	....	....	....	....	....	....
1902	301, 590, 434	11, 300	....	....	....	....	....	....
1903	357, 356, 416	288, 661	....	....	....	....	....	....
1904	351, 816, 398	608, 270	....	....	....	....	....	....
1905	392, 722, 635	1, 031, 300	....	....	....	....	....	....
1906	414, 157, 278	1, 533, 575	....	....	....	....	....	....
1907	480, 363, 424	2, 095, 244	....	....	....	....	....	....
1908	415, 842, 698	2, 108, 610	....	....	....	....	....	....
1909	460, 814, 616	8, 942, 857	....	....	....	....	....	....
1910	501, 596, 378	11, 820, 836	....	....	....	....	....	....
1911	496, 371, 126	13, 428, 239	....	....	27	....	....	....
1912	534, 466, 580	18, 150, 618	20, 903, 430	187, 091, 000	34	39	350	423
1913	570, 048, 125	21, 804, 285	24, 143, 133	184, 917, 075	38	42	325	405
1914	513, 525, 477	19, 593, 892	24, 215, 945	176, 812, 650	38	47	345	430
1915	531, 619, 487	21, 841, 659	22, 384, 025	167, 513, 950	41	42	315	398
1916	590, 098, 175	26, 566, 521	20, 901, 405	176, 976, 025	45	35	300	380
1917	651, 402, 374	32, 910, 397	28, 262, 807	235, 750, 300	51	43	362	456
1918	678, 211, 904	37, 262, 915	31, 368, 073	216, 221, 550	55	46	319	420
1919	[b] 546, 155, 000	32, 840, 196	29, 616, 383	153, 490, 125	60	54	281	395
1920	[b] 645, 663, 000	45, 222, 130	37, 273, 255	219, 762, 625	70	58	340	468

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[a] The figures show the relation which the consumption of each class of explosives bears to the total quantity of explosives used in the production of coal. Except in the last column they do not indicate the quantity of coal broken down by any given quantity of explosives.

[b] Estimated.

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TABLE 6.—*Quantity of explosives used in the different coal fields in the United States.*[a]

Coal fields and regions.	Black blasting powder (kegs).				High explosives other than permissible (pounds).			
	1917	1918	1919	1920	1917	1918	1919	1920
1. Pennsylvania anthracite field	1,430,169	1,212,172	1,018,685	923,423	16,074,125	16,709,256	17,800,259	19,278,375
2. Northern Appalachian region[b]	2,372,303	1,967,012	1,529,511	2,271,648	4,592,547	5,320,401	4,561,368	6,975,482
3. Southern Appalachian region	845,553	815,785	656,037	1,050,068	1,519,234	2,202,700	1,867,150	3,221,212
4. Eastern interior field	2,974,925	3,034,820	1,876,849	3,037,925	994,166	1,121,958	904,826	1,360,150
5. Western interior field	1,478,311	1,319,401	838,599	1,186,280	3,185,290	4,067,393	3,642,960	4,778,831
6. Rocky Mountain region	304,544	279,039	206,099	294,657	1,154,495	1,347,240	596,170	847,009
7. Pacific coast region	24,207	20,633	13,825	26,504	742,950	599,125	243,650	812,196
Total	**9,430,012**	**8,648,862**	**6,139,605**	**8,790,505**	**28,262,807**	**31,368,073**	**29,616,383**	**37,273,255**

Coal fields and regions.	Permissible explosives (pounds).								
	1912	1913	1914	1915	1916	1917	1918	1919	1920
1. Pennsylvania anthracite field	2,177,172	3,294,225	4,380,635	5,037,050	5,219,032	7,298,925	7,654,250	8,579,643	8,558,690
2. Northern Appalachian region[b]	9,190,025	9,744,810	7,966,464	9,435,318	12,147,207	14,505,542	17,007,369	14,626,371	22,489,169
3. Southern Appalachian region	3,995,485	4,481,975	3,510,013	3,447,964	4,386,757	5,287,755	5,764,886	4,210,184	5,573,168
4. Eastern interior field	751,005	2,058,075	1,364,450	1,631,775	1,949,925	2,403,600	2,873,846	2,542,290	3,906,872
5. Western interior field	440,825	377,625	411,937	433,010	422,425	624,045	930,444	642,938	1,187,171
6. Rocky Mountain region	1,473,129	1,634,575	1,796,750	1,710,992	2,244,275	2,423,180	2,622,520	1,882,770	2,744,360
7. Pacific coast region	122,977	213,000	163,643	145,550	196,900	367,350	409,600	356,000	762,700
Total	**18,150,618**	**21,804,285**	**19,593,892**	**21,841,659**	**26,566,521**	**32,910,397**	**37,262,915**	**32,840,196**	**45,222,130**

[a] The various coal fields include the following States: Group 1 includes the Pennsylvania anthracite field only; group 2 includes Pennsylvania bituminous, Maryland, West Virginia, Ohio, and Virginia; group 3 includes Alabama, Georgia, North Carolina, Tennessee, and Kentucky; group 4 includes Illinois, Indiana, and Michigan; group 5 includes Iowa, Missouri, Arkansas, Texas, Oklahoma, and Kansas; group 6 includes Colorado, Idaho, North Dakota, South Dakota, Montana, Utah, Wyoming, Nevada, and New Mexico; and group 7 includes Alaska, California, Oregon, and Washington.

[b] Not including Pennsylvania anthracite field.

TABLE 7.—*Quantity of coal mined in different coal fields in the United States.*

Coal fields and regions.	1912	1913	1914	1915	1916	1917	1918	1919	1920
1. Pennsylvania anthracite field	84,361,598	91,524,922	90,821,507	88,995,061	87,578,493	99,611,811	98,826,084	88,092,000	89,100,000
2. Northern Appalachian region [a]	275,991,578	294,898,633	250,627,117	269,876,970	305,651,290	314,471,558	329,086,628	268,320,000	309,400,000
3. Southern Appalachian region	39,292,052	44,454,532	42,085,941	42,154,468	49,791,197	54,189,294	57,696,763	48,945,000	54,539,000
4. Eastern interior field	76,377,174	80,016,201	75,513,359	76,991,866	87,469,224	114,113,521	121,434,557	86,030,000	121,910,000
5. Western interior field	26,580,416	27,875,292	26,396,916	25,684,804	26,474,830	30,707,592	30,723,823	22,590,000	29,930,000
6. Rocky Mountain region	28,449,860	27,327,452	24,950,285	25,434,089	30,031,648	34,209,991	36,266,503	28,998,000	36,940,000
7. Pacific Coast region	3,413,902	3,951,093	3,130,352	2,482,229	3,101,493	4,098,607	4,177,546	3,180,000	3,844,000
Total	**534,466,580**	**570,048,125**	**513,525,477**	**531,619,487**	**590,098,175**	**651,402,374**	**678,211,904**	**546,155,000**	**645,663,000**

[a] Not including Pennsylvania anthracite field.

MINE FATALITIES DUE TO EXPLOSIVES.

Accidents in the mining industry due to the use of explosives during the past nine years have caused from 4 to 9 per cent of all fatalities at coal mines, 9 to 14 per cent at metal mines, and 13 to 26 per cent at quarries. Considered in relation to the number of men employed, there has been a general decline in the number of such fatalities, although the rate has fluctuated from year to year, as shown by Table 8. Fatalities at coal mines since 1911 are shown in Table 9. The figures presented in the table show that from 37 to 61 per cent of the fatalities occurred at the anthracite mines in Pennsylvania. In 1919 the figure for anthracite mines was abnormally high (149, or 72 per cent) due to a powder explosion in Baltimore Tunnel No. 2, at Wilkes-Barre, on June 5, which caused the death of 92 men.

Table 10 shows the causes of fatalities due to explosives in the mining industry in 1919. Exclusive of the powder explosion at the Baltimore Tunnel, 46 per cent of the accidents were caused by premature shots.

TABLE 8.—*Fatalities due to explosives at mines and quarries, and fatality rates per 1,000 men employed (300-day workers).*

	Bituminous coal mines.			Anthracite and bituminous mines.			Metal mines.			Quarries.		
	Killed.	Per cent.	Rate.	Killed.	Per cent.	Rate.	Killed.	Per cent.	Rate.	Killed.	Per cent.	Rate.
1901	......	......	......	......	......	......	......	......	......	......	......	......
1902	......	......	......	......	......	......	......	......	......	......	......	......
1903	138	9.80	......	......	......	......	......	......	......	......	......	......
1904	121	8.64	......	......	......	......	......	......	......	......	......	......
1905	119	7.49	......	......	......	......	......	......	......	......	......	......
1906	115	7.27	......	......	......	......	......	......	......	......	......	......
1907	134	5.29	......	......	......	......	......	......	......	......	......	......
1908	109	6.17	......	......	......	......	......	......	......	......	......	......
1909	122	5.88	......	......	......	......	......	......	......	......	......	......
1910	113	5.09	......	......	......	......	......	......	......	......	......	......
1911	72	3.68	.184	160	6.02	.299	78	11.22	.500	50	26.60	.592
1912	70	3.85	.171	147	6.08	.271	94	14.22	.581	47	22.06	.501
1913	63	2.91	.142	138	4.96	.232	89	13.03	.485	44	24.04	.505
1914	56	3.01	.147	146	5.95	.277	60	10.73	.421	35	19.44	.513
1915	76	4.52	.202	155	6.83	.303	78	14.10	.549	28	18.92	.339
1916	60	3.59	.139	146	6.56	.258	89	12.77	.462	28	16.18	.366
1917	55	2.60	.112	110	4.08	.173	79	9.27	.411	21	16.03	.294
1918	85	4.19	.166	135	5.23	.206	89	13.78	.492	17	13.60	.286
1919	57	3.39	......	206	8.89	......	48	10.26	.352	24	19.51	.376
1920	78	4.40	......	127	5.62	......	......	......	......	......	......	......

TABLE 9.—*Coal-mine fatalities underground due to explosives, 1911–1920.*

States.	1911	1912	1913	1914	1915	1916	1917	1918	1919	1920
Pennsylvania (anthracite)	88	77	75	90	79	86	55	50	[a] 149	49
Pennsylvania (bituminous)	6	8	4	7	9	10	6	6	17	22
West Virginia	3	8	8	5	6	3	6	14	6	12
Illinois	15	11	11	9	11	6	9	12	2	9
Ohio	3	5	6	2	3	5	4	8	10	9
Indiana, Michigan, and Kentucky	15	3	5	12	12	10	14	20	11	9
Alabama, Tennessee, Georgia, and North Carolina	6	6	2	2	10	3	3	5	3	6
Iowa, Kansas, and Missouri	4	14	6	4	13	9	2	7	2	3
Colorado, New Mexico, and Utah	3	1	7	4	......	4	3	3	1	4
Maryland and Virginia	......	10	2	......	4	3	2	5	2	......
Montana, North Dakota, and Wyoming	4	2	4	4	3	2	2	1	2	1
Arkansas, Oklahoma, and Texas	11	1	5	4	5	1	4	4	......	3
Alaska, California, Idaho, Nevada, Oregon, and Washington	2	1	3	3	......	4	......	......	1	......
Total, underground	**160**	**147**	**138**	**146**	**155**	**146**	**110**	**135**	**206**	**127**

[a] Of this number, 92 men were killed in the powder explosion in Baltimore Tunnel No. 2, Wilkes-Barre, Pa., on June 5, 1919.

TABLE 10.—*Fatal accidents due to explosives in the mineral industry, 1919.*

	Transportation.	Charging.	Suffocation.	Drilling into old holes.	Striking into loose rock or ore.	Thawing.	Caps, detonators, etc.	Unguarded shots.	Returned too soon.	Premature shots.	Sparks from match, lamp, or candle.	Delayed blast.	Shot breaking through rib or pillar.	Miscellaneous.	Total.
Quarries	....	3	....	2	....	....	2	....	3	8	....	2	....	4	24
Coal mines (underground)	97	14	3	....	....	....	3	3	5	56	7	2	6	10	206
Metal mines (underground)	....	....	2	....	....	....	....	....	3	5	....	....	....	1	[a] 11
Metal mines (open pit)	....	....	....	....	....	....	....	....	....	....	....	....	....	1	[a] 1
Total	**97**	**17**	**5**	**2**	....	....	**5**	**3**	**11**	**69**	**7**	**4**	**6**	**16**	**242**

[a] From selected returns only. Details as to subdivisions not available for all metal mines. See Table 9.

TABLE 11.—*Percentage of explosives used for various purposes in the United States during the years 1915 to 1920.*

	Coal mining.	Other mining.	Railway and other construction work.	All other purposes.	Total.
1920.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Black blasting powder	86. 2	3. 4	1. 9	8. 5	100. 00
High explosives	16. 3	38. 9	6. 6	38. 2	100. 00
Permissible explosives	83. 8	6. 9	. 5	8. 8	100. 00
Total	**56. 2**	**18. 9**	**3. 7**	**21. 2**	**100. 00**
1919.					
Black blasting powder	85. 0	3. 5	2. 8	8. 7	100. 00
High explosives	14. 9	45. 3	6. 4	33. 4	100. 00
Permissible explosives	84. 5	6. 4	. 5	8. 6	100. 00
Total	**51. 7**	**23. 6**	**4. 3**	**20. 4**	**100. 00**
1918.					
Black blasting powder	87. 7	3. 0	2. 2	7. 1	100. 00
High explosives	15. 2	49. 6	5. 8	29. 4	100. 00
Permissible explosives	80. 9	9. 9	. 4	8. 8	100. 00
Total	**57. 1**	**22. 9**	**3. 5**	**16. 5**	**100. 00**
1917.					
Black blasting powder	85. 1	3. 4	4. 7	6. 8	100. 00
High explosives	10. 8	50. 4	7. 8	31. 0	100. 00
Permissible explosives	76. 5	14. 2	. 2	9. 1	100. 00
Total	**51. 0**	**25. 4**	**5. 7**	**17. 9**	**100. 00**
1916.					
Black blasting powder	82. 1	3. 6	5. 0	9. 3	100. 00
High explosives	8. 2	51. 6	8. 6	31. 6	100. 00
Permissible explosives	76. 6	17. 9	. 3	5. 2	100. 00
Total	**44. 4**	**28. 8**	**6. 5**	**20. 3**	**100. 00**
1915.					
Black blasting powder	84. 8	3. 4	3. 6	8. 2	100. 00
High explosives	9. 5	46. 3	9. 4	34. 9	100. 00
Permissible explosives	79. 9	17. 1	. 5	2. 5	100. 00
Total	**45. 9**	**26. 1**	**6. 4**	**21. 5**	**100.00**

TABLE 12.—*Production of explosives in the United States from 1912 to 1920.*

[Excluding exports.]

	1912	1913	1914	1915	1916	1917	1918	1919	1920
Black blasting powder (kegs of 25 pounds):									
Quantity used for coal mining	7,483,640	7,396,683	7,072,506	6,700,558	7,079,041	9,430,012	8,648,862	6,139,605	8,790,505
Quantity used for other mining	1,728,095	334,014	302,885	268,146	313,851	378,199	297,818	252,134	347,223
Quantity used for railway and other construction work		626,474	316,131	289,869	428,853	516,892	219,260	204,197	196,172
Quantity used for all other purposes		840,410	552,466	650,319	801,256	759,638	700,594	624,506	861,293
Total	**9,211,735**	**9,197,581**	**8,243,988**	**7,908,892**	**8,623,001**	**11,084,741**	**9,866,534**	**7,220,442**	**10,195,193**
High explosives other than permissible (pounds):									
Quantity used for coal mining	20,903,430	24,143,133	24,215,945	22,384,025	20,901,405	28,262,807	31,368,073	29,616,383	37,273,255
Quantity used for other mining	89,703,081	92,096,426	84,264,577	109,128,966	131,753,648	132,235,515	102,366,876	89,754,788	89,132,316
Quantity used for railway and other construction work	123,862,981	33,173,805	27,984,946	22,279,699	21,905,376	20,418,227	12,081,541	12,759,623	15,052,608
Quantity used for all other purposes		92,973,180	81,989,503	82,035,897	80,594,358	81,399,531	60,599,587	66,137,794	87,653,905
Total	**234,469,492**	**242,386,544**	**218,453,971**	**235,828,587**	**255,154,787**	**262,316,080**	**206,416,077**	**198,268,588**	**229,112,084**
Permissible explosives (pounds):									
Quantity used for coal mining	18,150,618	21,804,285	19,593,892	21,841,659	26,566,521	32,910,397	37,262,915	32,840,196	45,222,130
Quantity used for other mining	4,668,399	4,735,480	4,850,241	4,687,510	6,206,558	6,102,225	4,550,130	2,498,132	3,750,585
Quantity used for railway and other construction work	1,811,253	424,575	281,425	139,843	97,100	136,185	184,380	183,353	266,505
Quantity used for all other purposes		721,430	972,260	680,897	1,815,061	3,921,915	4,048,808	3,333,151	4,723,621
Total	**24,630,270**	**27,685,770**	**25,697,818**	**27,349,909**	**34,685,240**	**43,040,722**	**46,045,233**	**38,854,832**	**53,962,841**

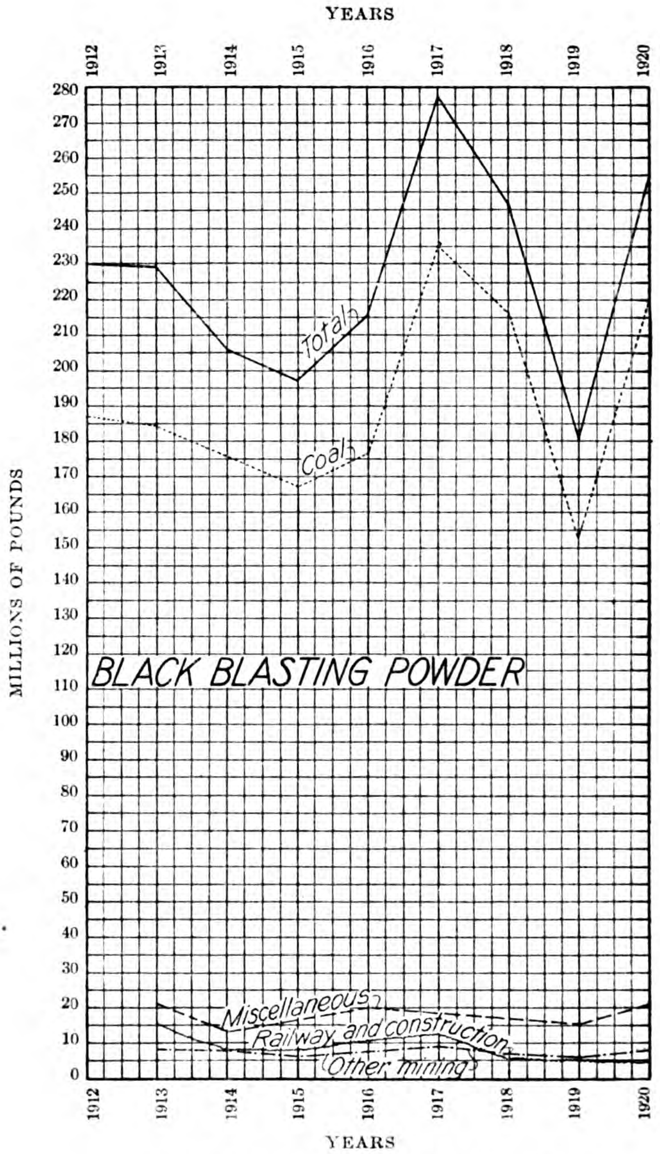


FIG. 1. Consumption of black powder, 1912–1920

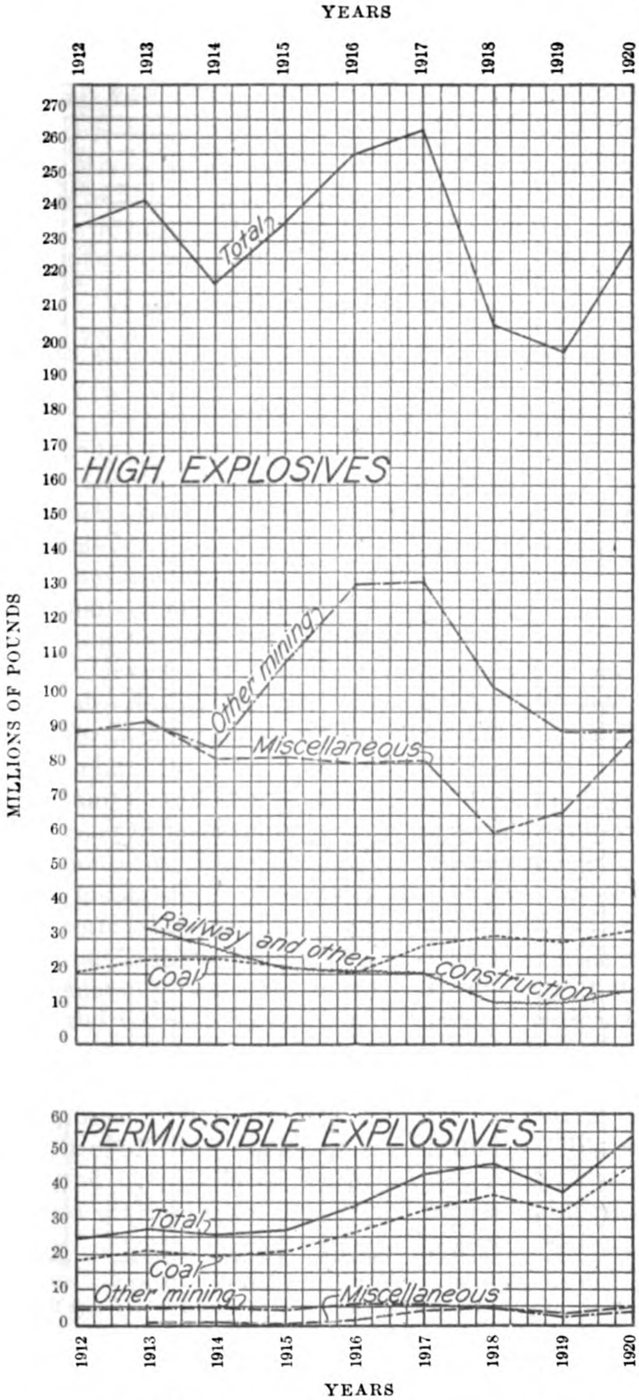
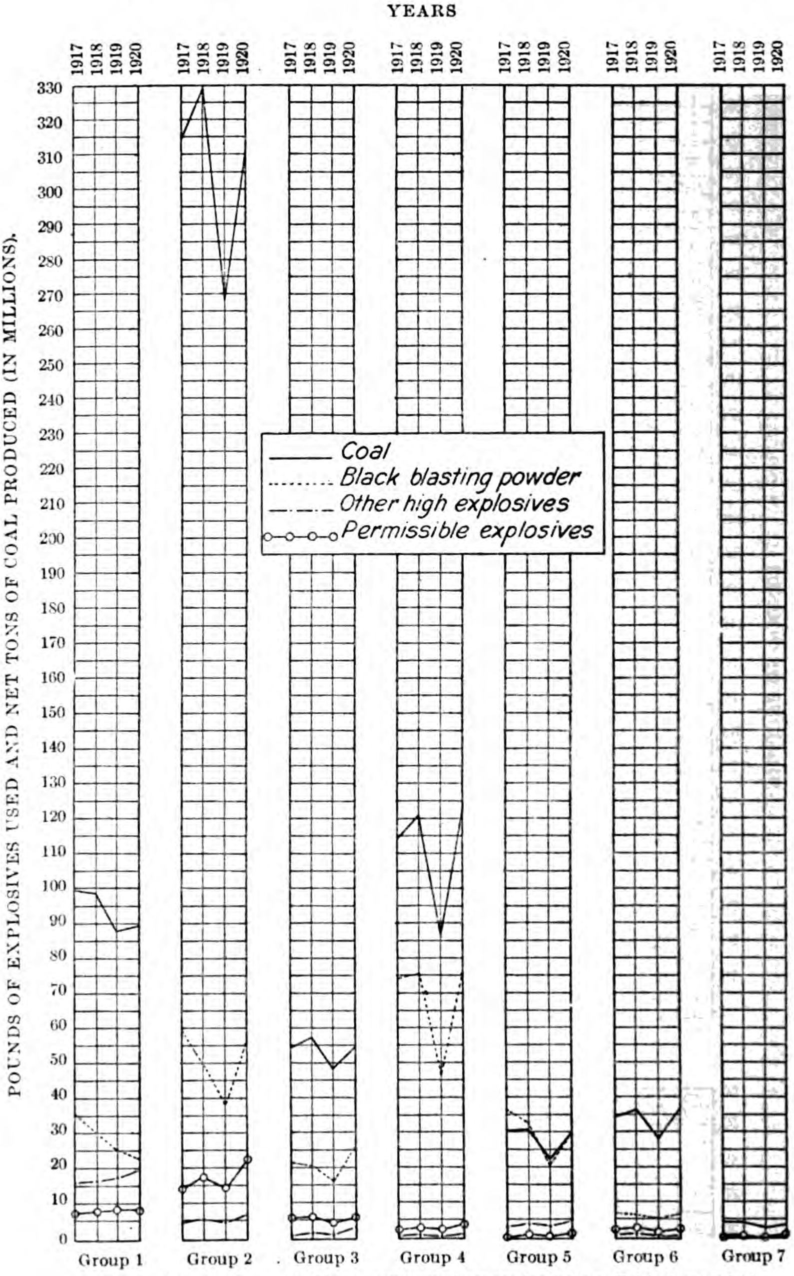


FIG. 2. Consumption of high explosives and permissible explosives, 1912–1920



[Note: For significance of these group numbers see footnote [a], Table 6, page 13.]

FIG. 3. Production of coal and consumption of explosives at coal mines, by geographic areas, 1917-1920.

AMMONIUM NITRATE IN PERMISSIBLE EXPLOSIVES.

At the close of the calendar year 1920 the bureau received special reports from all manufacturers of permissible explosives showing the quantity of each brand of permissible sold during the year. A study of these reports by S. P. Howell, explosives engineer of the Bureau of Mines, shows that 90 per cent of all permissible explosives sold during 1920 belonged to the ammonium nitrate class (Class 1–A). The total quantity of commercial ammonium nitrate used in permissible explosives during 1920 aggregated 31,831,000 pounds.

MONTHLY SALES OF EXPLOSIVES.

Table 13 shows the monthly fluctuations in the sales of explosives during the past year; it is based on monthly reports by manufacturers who are members of the Institute of Makers of Explosives. Most of the manufacturing companies are members of the institute, and their sales during 1920 represented more than 90 per cent of all sales of black blasting powder, 92 per cent of high explosives (other than permissibles), and over 99 per cent of permissible explosives. Reports from nonmembers are received by the bureau in the form of an annual summary, hence it was not possible to segregate on a monthly basis the data for those companies.

The standard chosen for purposes of comparison was the average monthly sales during the year, and this quantity was rated at 100. The sales for each month were then calculated as a certain percentage of this standard.

An examination of the table will show that April was the month of lowest sales of black powder and permissible explosives, as it was also the month of smallest production of bituminous coal, in which branch of mining these two classes of explosives are so largely used. Sales of permissibles and black powder were, however, reasonably steady throughout the year. Sales of "high" explosives in January were considerably below the average for the year, but in February a substantial increase occurred and continued with a fair degree of steadiness until the close of September, after which there was a rapid decline to the close of the year, the lowest quantity sold being recorded for December.

Sales reached their highest mark in June in the case of black powder, and in September for permissible explosives, whereas the bituminous coal industry showed the largest production of coal in October.

TABLE 13.—*Monthly fluctuations in sales of explosives and in production of coal, 1920.*

[Average monthly quantities = 100 per cent.]

Month.	Black blasting powder.	"High" explosives.	Permissible explosives.	Bituminous coal.	Anthracite.	Total coal.
January	109.1	87.9	99.9	105.0	102.2	104.6
February	99.4	103.1	87.1	86.5	87.9	86.7
March	107.6	126.7	98.4	100.9	105.8	101.6
April	74.6	107.0	82.3	81.8	83.8	82.1
May	95.2	108.8	94.7	85.7	107.2	88.7
June	114.7	107.5	98.8	94.4	110.0	96.5
July	109.2	93.7	103.5	98.2	111.3	100.0
August	108.8	120.6	113.3	104.3	108.1	104.8
September	92.6	105.1	116.6	106.1	[a] 62.6	100.1
October	108.4	94.5	115.1	113.5	108.7	112.8
November	91.3	74.4	94.3	110.0	100.4	108.7
December	89.1	70.7	96.2	113.7	112.1	113.5

[a] A strike in the anthracite field restricted output.

EXPORTS OF EXPLOSIVES, 1913–1920.

Table 14 shows the amount and value of explosives exported from the United States during the years 1913 to 1920, inclusive. The tabulations of exports unfortunately do not segregate such explosives as picric acid, nitroglycerin, trinitrotoluene, and others. These are grouped in the column headed "All other."

Table 15 shows the amount and value of explosives exported from the United States during 1920 and the countries to which the shipments were made. The largest shipments of the year were those of loaded shells and projectiles to Russia in Europe during January and of gunpowder to France during October.

TABLE 14.—*Explosives exported from the United States, 1913–1920.*[a]

Years and Months.	Cartridges.	Dynamite.		Gunpowder (including smokeless).		Fuses.	Shells and projectiles, loaded.	All other.	Total.
	Value.	Pounds.	Value.	Pounds.	Value.	Value.	Value.	Value.	Value.
1920.									
January	$486,101	1,059,470	$205,220	238,176	$98,621	$34,863	$5,388,746	$346,216	$6,559,767
February	432,785	802,399	170,252	63,447	26,566	74,390	52,751	213,447	970,191
March	1,037,211	1,781,445	361,166	183,117	86,812	71,955	94,774	199,296	1,851,214
April	448,743	1,115,781	231,917	236,191	101,434	46,844	105,108	177,281	1,111,327
May	648,356	1,648,445	352,866	133,987	69,972	91,669	106,997	247,719	1,517,579
June	615,015	734,234	150,039	120,316	34,157	64,203	143,588	111,725	1,118,727
July	398,383	3,061,765	620,079	164,317	90,764	60,477	71,100	223,332	1,464,135
August	315,827	1,002,740	205,477	138,907	54,703	84,020	66,595	193,429	920,051
September	445,899	1,396,834	258,861	7,197,233	7,192,583	33,595	31,850	119,228	8,082,016
October	450,895	1,728,169	350,586	21,526,436	21,488,601	68,855	63,733	233,884	22,656,554
November	365,439	518,954	120,509	4,403,382	4,372,204	47,458	52,680	121,681	5,079,971
December	327,668	791,745	183,509	9,502,284	4,751,740	57,896	100,112	94,241	5,515,166
Total	**5,972,322**	**15,641,981**	**3,210,481**	**43,907,793**	**38,368,157**	**736,225**	**6,278,034**	**2,281,479**	**56,846,698**
1919.									
January	311,519	1,709,120	429,231	12,638	10,345	43,250	67,235	364,744	1,226,324
February	295,108	954,445	222,915	109,324	59,227	117,278	168,770	178,809	1,042,107
March	1,896,511	509,646	108,192	118,494	70,322	23,140	56,898	221,466	2,376,529
April	395,470	678,412	126,181	96,702	45,466	21,200	25,654	129,147	743,118
May	483,759	803,486	179,476	5,508,489	5,444,565	28,248	26,613	178,372	6,341,033
June	902,864	1,094,136	255,969	159,395	67,984	41,864	52,166	262,961	1,583,808
July	470,541	518,260	91,534	33,951	17,976	63,077	13,967	90,392	747,487
August	4,014,279	1,251,520	246,918	201,296	60,556	35,949	134,317	165,292	4,657,311
September	428,398	1,321,660	233,114	92,428	38,396	76,339	57,092	135,618	968,957
October	345,302	635,976	139,895	97,001	39,635	27,357	38,082	74,094	664,365
November	397,455	978,464	184,559	76,132	35,092	46,848	6,114,025	228,125	7,006,104
December	405,751	718,403	152,032	245,949	101,180	76,168	46,072	261,361	1,042,564
Total	**10,346,957**	**11,173,528**	**2,370,016**	**6,751,799**	**5,990,744**	**600,718**	**6,800,891**	**2,290,381**	**28,399,707**
Total, 1918	**10,764,765**	**18,204,644**	**4,845,888**	**229,377,058**	**179,648,156**	**3,050,257**	**3,812,608**	**41,406,865**	**243,528,539**
Total, 1917	**42,122,656**	**17,930,665**	**3,953,374**	**438,459,254**	337,904,687	[b]**16,945,589**	[b]**36,755,525**	202,252,574	**639,934,405**
Total, 1916	**55,103,904**	**18,681,285**	**4,173,175**	**313,648,981**	262,161,893	(c)	(c)	394,136,334	715,575,306
Total, 1915	**25,408,079**	**11,446,368**	**1,509,050**	**84,358,379**	**66,922,807**	(c)	(c)	**95,129,957**	188,969,893
Total, 1914	**6,567,122**	**11,303,315**	**1,213,600**	**866,569**	**289,893**	(c)	(c)	**1,966,972**	**10,037,587**
Total, 1913	**3,015,399**	**13,403,616**	**1,498,222**	**1,284,422**	**359,855**	(c)	(c)	**651,601**	**5,525,077**

[a] Compiled from "Monthly Summary of Foreign Commerce of the United States," published by the Bureau of Foreign and Domestic Commerce, Department of Commerce.
[b] July 1 to Dec. 31.
[c] Not segregated.

TABLE 15.—*Explosives exported from the United States, by countries, in 1920 and 1919.*[a]

Countries.	Cartridges.	Dynamite.		Gunpowder.		Fuses.	Shells.	All other.	Total, 1920.	Total, 1919.
	Value.	Pounds.	Value.	Pounds.	Value.	Value.	Value.	Value.	Value.	Value.
Azores and Madeira Islands	$325							$336	$661	
Belgium	36,336			266,829	$133,414	$5,160	$12,693	81	187,684	$30,778
Denmark	14,297						1,499	90	15,886	1,417,359
Finland	12,192			370	320		945	2,939	16,396	16,115
France	407			42,191,861	37,579,793	2,548		78,987	37,661,735	95,246
Germany	5,142								5,142	
Greece	44,138			101,940	81,111	458	19,851	25,891	171,449	74,478
Iceland and Faroe Islands	2,067			5,855	3,231		367	214	5,879	14,822
Italy	13,889						200	178,685	192,774	486,207
Malta, Gozo, and Cyprus Islands	495							5	500	1,187
Netherlands	880			6	7	81	30	60	1,058	5,661
Norway	24,326					280	15,932	7,263	47,801	155,579
Poland and Danzig	5								5	
Portugal	6,697						3,035	26,388	36,120	25,232
Rumania	20								20	
Russia in Europe	100,000						5,344,810		5,444,810	9,608,940
Spain	73,923					5	171	13,924	88,023	82,313
Sweden	19,016					25	2,445	24,043	45,529	245,143
Switzerland	1,239					95		50	1,384	1,950
Turkey in Europe	1,016					194	8		1,218	
England	165,199			140	179	8,955	814	7,836	182,983	5,595,395
Scotland	777							1,409	2,186	500
Ireland										202
Bermuda	334	150	$37			86		207	664	136
British Honduras	3,181	5,350	1,726	7,838	3,037	360	13,712	976	22,992	25,166
Canada	441,191	108,085	26,097	251,481	103,627	39,928	59,238	541,369	1,211,450	712,851
Costa Rica	13,345	235,000	43,863	17,120	6,830	14,988	318	11,831	91,175	25,914
Guatemala	3,810	5,060	1,492	43,000	14,759	550		7,514	28,125	18,850
Honduras	19,206	404,270	72,935	3,625	317	19,002	1,746	25,228	138,434	108,193
Nicaragua	22,250	267,626	57,119	12,560	6,873	12,370	1,537	18,070	118,219	134,927
Panama	30,475	181,148	50,364	32,074	12,263	1,006	7,327	10,906	112,341	111,745
Salvador	10,790	32,300	6,139	17,500	7,100	1,920	43	4,763	30,755	103,332
Mexico	40,876	7,835,824	1,456,908	88,603	16,426	359,529	12,797	327,873	2,214,409	1,808,395
Miquelon, Langley, etc										202
Newfoundland and Labrador	20,976					321	7,897	938	30,132	30,699
Barbados	1,061					172	499	108	1,840	1,406
Jamaica	5,237	39,700	8,566	2,642	910	6	1,739	3,569	20,027	10,556

[a] Compiled from "Monthly Summary of Foreign Commerce of the United States," published by the Bureau of Foreign and Domestic Commerce, Department of Commerce.

TABLE 15.—*Explosives exported from the United States, by countries, in 1920 and 1919*[a]—Continued.

Countries.	Cartridges.	Dynamite.		Gunpowder.		Fuses.	Shells.	All other.	Total, 1920.	Total, 1919.
	Value.	Pounds.	Value.	Pounds.	Value.	Value.	Value.	Value.	Value.	Value.
Trinidad and Tobago	$2,718					$170	$2,459	$3,923	$9,270	$15,929
Other British West Indies	2,892	152	$55	425	$153	26	1,060	1,317	5,503	5,365
Cuba	307,843	915,642	208,342	127,586	51,726	36,447	165,412	83,046	852,816	592,310
Virgin Islands of United States	699	200	150	20	24	56	565	997	2,491	502
Dutch West Indies	1,037			75	25		185	1,295	2,542	467
French West Indies	785			670	251	134	40	106	1,316	442
Haiti	665						153	1,080	1,898	1,974
Dominican Republic	487	6,995	2,271	72	45	222	526	22,070	25,621	10,587
Argentina	798,340	5,000	1,713	22,009	13,415	2,006	33,393	8,077	856,944	784,320
Bolivia	29,091	230,000	63,060	7,577	5,317	532	5,283	16,445	119,728	157,230
Brazil	1,773,049	147,850	52,739	6,295	4,161	19,993	40,245	112,088	2,002,275	1,156,569
Chile	124,470	2,350,552	498,790	9,859	5,082	38,522	27,845	167,059	861,768	818,319
Colombia	142,575	93,020	28,155	311,479	115,731	7,104	7,862	102,611	404,038	268,582
Ecuador	42,075	126,500	28,231	61,083	27,133	234	406	8,132	106,211	68,945
British Guiana	1,067	13,627	3,595			407		14,906	19,975	8,583
Dutch Guiana	268	50,000	10,000				260	3,659	14,187	2,232
French Guiana	28							55	83	102
Paraguay	33,423						640	440	34,503	9,006
Peru	126,234	1,673,935	336,573	67,659	62,790	84,704	3,166	147,981	761,448	495,183
Uruguay	94,459	25,000	8,900	39,300	15,071	1,548	11,295	6,622	137,895	88,187
Venezuela	5,483	7,640	1,832	81,213	37,825	1,367	167	40,928	87,602	108,079
China	10,761	159,000	46,719	600	400	11,621	5,801	44,285	119,587	149,822
Kwantung, leased territory	10,341							1,029	11,370	24,794
Chosen	1,972								1,972	12,530
British India	30,760			450	290	2,095	2,336	4,836	40,317	200,536
Straits Settlements	7,749						4,459	781	12,989	17,556
Other British East Indies	3,511						794	504	4,809	18,756
Dutch East Indies	14,168	420,060	129,205	60,000	18,780	48,751	2,042	71,720	284,666	186,271
French East Indies	1,859							1	1,860	5,730
Hongkong	5,865			2,500	912	240	1,491	114	8,622	12,791
Japan	35,221	75,000	23,039			2,360	1,876	12,216	74,712	156,606
Russia in Asia	56,101			6,397	4,095		562	8,396	69,154	181,939
Siam				33,600	26,880			451	27.331	532
Turkey in Asia	3						216	15	234	
Australia	763,038					352	333,004	41,589	1,137,983	1,055,753
New Zealand	181,043	25,000	4,063	3,852	4,125	507	32,085	3,782	225,605	177,006
Other British Oceania	2,400						809	70	3,279	3,477
French Oceania	2,350	7,160	2,269	400	108	28	7	903	5,665	2,113
Other Oceania	6,473			1,000	501		593		7,567	7,057
Philippine Islands	91,518	195,135	35,534	20,250	3,120	8,253	56,802	12,780	208,007	211,625

Belgian Kongo	280	....	....	....	....	....	3,257	....	3,537	1,836
British West Africa	1,854	....	....	....	....	30	318	8,150	10,352	57,176
British South Africa	85,054	....	....	....	....	358	6,249	793	92,454	274,110
British East Africa	6,983	....	....	....	....	....	862	....	7,845	23,382
Canary Islands	1,693	....	....	....	....	....	908	191	2,792	475
French Africa	2,108	....	....	....	....	....	75	10	2,193	2,935
Kamerun, etc	58	....	....	....	....	....	466	....	524	175
Liberia	801	....	....	....	....	....	65	993	1,859	840
Morocco	2,497	....	....	....	....	....	....	100	2,597	....
Portuguese Africa	5,416	....	....	....	....	119	940	29	6,504	12,982
Egypt	17,639	....	....	....	....	....	11,402	3,351	32,392	58,510
Total, 1920	**5,972,322**	**15,641,981**	**3,210,481**	**43,907,793**	**38,368,157**	**736,225**	**6,278,034**	**2,281,479**	**56,846,698**	....
Total, 1919	**10,346,957**	**11,173,528**	**2,370,016**	**6,751,799**	**5,990,744**	**600,718**	**6,800,891**	**2,290,381**	....	**28,399,707**

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[a] Compiled from Monthly Summary of Foreign Commerce of the United States, published by the Bureau of Foreign and Domestic Commerce, Department of Commerce.

NOTE.—There were no exports in 1919 or 1920 to the following countries: Austria, Bulgaria, Czechoslovakia, Gibraltar, Hungary, Jugoslavia, Albania, etc., Greenland, Falkland Islands, Aden, Portuguese East Indies, Persia, other Asia, Abyssinia, Italian Africa, Madagascar, and Spanish Africa.

PERMISSIBLE EXPLOSIVES TESTED PRIOR TO JUNE 1, 1921.

By Spencer P. Howell.

GENERAL STATEMENT.

In the table following are the brand names of all explosives now considered as permissible explosives that were tested by the Bureau of Mines prior to June 1, 1921.

Further information on permissible explosives may be found in other Bureau of Mines publications.[1] The precautions to be observed in the handling, storage, and use of permissible explosives are found in Miner's Circular 6. The conditions to be fulfilled by applicants desiring explosives tested to determine their permissibility for use in coal mines are stated in Schedule 1–A. A description of the tests made, the apparatus used for such tests, and detailed results of tests of 100 permissible explosives are given in Bulletins 15 and 66. The storage, handling, and use of permissible explosives are discussed in Bulletins 10 and 17 and Miner's Circular 7, and the methods used by the bureau in the analysis of permissible explosives and the tolerances for permissible explosives as promulgated by the Bureau of Mines on July 1, 1915, are detailed in Bulletin 96, and on November 15, 1920, and February 26, 1921, and effective from those dates the Director of the Bureau of Mines promulgated certain changes in the rules and regulations governing the testing of permissible explosives, as recommended by the bureau's committee on permissible explosives. The tolerances as now existing are given on pages 39, 40, and 41. These rules also provide for the transferring of permissible explosives from the active (published) list to the inactive (not published) list. Explosives will be placed on the inactive list at the request of the manufacturer or if they have not been manufactured during any calendar year.

Additions to the active and inactive list of permissible explosives will be published in future issues of the Monthly Statement of Coal-Mine Fatalities in the United States, which contains also lists of miners' electric lamps and other devices approved by the Bureau of Mines. A complete list of permissible explosives with pertinent data and full descriptive text will be published as an appendix to the same publication at reasonable intervals of from 6 to 12 months.

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[1] Hall, Clarence, Permissible explosives tested prior to Jan. 1, 1912, and precautions to be taken in their use: Miner's Circular 6, Bureau of Mines, 1912, 20 pp.: Fees for testing explosives: Schedule 1-A, Bureau of Mines, 1920; Hall, Clarence, Snelling, W. O., and Howell, S. P., Investigations of explosives used in coal mines: Bull. 15, Bureau of Mines, 1911, 191 pp.: Hall, Clarence, and Howell, S. P., Tests of permissible explosives: Bull. 66, Bureau of Mines, 1913, 313 pp.; Munroe, C. E., and Hall, Clarence, A primer on explosives for coal miners: Bull. 17, Bureau of Mines, 1911, 61 pp.; Rutledge, J. J., and Hall, Clarence, The use of permissible explosives: Bull. 10, Bureau of Mines, 1912, 34 pp.; Storm, C. G., The analysis of permissible explosives: Bull. 96, Bureau of Mines, 1916, 88 pp.; Rutledge, J. J., The use and misuse of explosives in coal mining: Miner's Circular 7, Bureau of Mines, 1913, 52 pp.; Howell, S. P., and Tiffany, J. E., Methods for routine work in the explosives physical laboratory of the Bureau of Mines: Tech. Paper 186, Bureau of Mines, 1918, 63 pp.

There were 148 explosives on the permissible list on January 31, 1921.[1] During the succeeding 4 months 6 explosives were added to the list. The present list takes the place of all preceding lists and includes a total of 154 explosives.

DEFINITION OF A PERMISSIBLE EXPLOSIVE.

A permissible explosive is an explosive which is similar in all respects to the sample which has passed certain tests prescribed by the Bureau of Mines to determine its safety for use in gaseous and dusty coal mines, when used in accordance with the conditions prescribed by the Bureau.

While permissible explosives are designed especially for use in gaseous and dusty coal mines, they are suitable for use in other coal mines and for many other blasting operations.

PRESCRIBED CONDITIONS FOR USE OF PERMISSIBLE EXPLOSIVES.

1. That the explosive is in all respects similar to the sample submitted by the manufacturer for test.
2. That detonators—preferably electric detonators—are used of not less efficiency than those prescribed, namely, those consisting by weight of 90 parts of mercury fulminate and 10 parts of potassium chlorate (or their equivalents).
3. That the explosive, if frozen, shall be thoroughly thawed in a safe and suitable manner before use.
4. That the quantity used for a shot does not exceed 1½ pounds (680 grams), and that it is properly tamped with clay or other noncombustible stemming.

After an explosive has passed the required tests and its brand name has been published in a list of permissible explosives, it is not a permissible explosive if one or more of any of the following conditions prevail:

1. If kept in a moist place until it undergoes a change in character.
2. If used in a frozen or partly frozen condition.
3. If used in excess of 1½ pounds (680 grams) per shot.
4. If the diameter of the cartridge is less than that designated in the column "smallest permissible diameter."
5. If fired with a detonator or electric detonator of less efficiency than that prescribed.
6. If fired without stemming.
7. If fired with combustible stemming.
8. If fired in the presence of a dangerous percentage of firedamp.

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[1] W. W. Adams, Coal-mine fatalities in the United States, 1920: Tech. Paper 288, Bureau of Mines, 1921, 112 pp.

Original from UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

Moreover, even when all of the prescribed conditions have been met, no explosive on the permissible list should necessarily be considered as being *permanently* a permissible explosive, for the bureau reserves the right, on fuller information concerning the conditions that lead to safety, to revise this list; but any permissible explosive when used under the prescribed conditions may properly continue to be considered a permissible explosive until notice of its withdrawal or removal from the list has been officially published, or until its name is omitted from a later list published by the Bureau of Mines.

After further experiments and conferences the Bureau of Mines may find it advisable to adopt additional and more severe tests to which all permissible explosives may be subjected, in the hope that through the use of such explosives only as pass the more severe tests the lives of miners may be better safeguarded.

LIST OF PERMISSIBLE EXPLOSIVES.

Subject to the conditions and provisions stated herein, the following explosives are classed as permissible explosives:

Permissible explosives tested prior to June 1, 1921.

Brand.	Class designation basis.		When used with detonators, preferably electric detonators, of not less efficiency than—	Weight of 1¼ by 8 inch cartridge.	Smallest permissible diameter.	Unit deflective charge.	Rate of detonation in 1¼-inch diameter cartridges.		Manufacturer.
	Volume of poisonous gases.	Characteristic ingredient.							
1	2	3	4	5	6	7	8		9
				Grams.	*Inches.*	*Grams.*	*Feet per second.*	*Meters per second.*	
Ætna coal powder A	C	4	No. 6	184	1¼	277	12,620	3,848	Ætna Explosives Co. (Inc.), New York, N. Y.
Ætna coal powder AA	A	1a	do	[a] 214	1¼	241	7,880	2,403	Do.
Ætna coal powder B	C	4	do	179	1¼	331	9,870	3,008	Do.
Ætna coal powder B+	C	do	do	192	1¼	288	9,760	2,977	Do.
Ætna coal powder C	B	do	do	198	1¼	344	7,010	2,138	Do.
Ætna coal powder 2	A	1a	do	186	1⅛	212	9,280	2,830	Do.
Austin Red Diamond No. 1–A	B	do	do	179	1¼	216	11,700	3,568	Austin Powder Co., Cleveland, Ohio.
Austin Red Diamond No. 2–A	B	do	do	178	⅞	239	9,870	3,009	Do.
Austin Red Diamond No. 3–A	B	do	do	174	⅞	243	7,260	2,212	Do.
Austin Red Diamond No. 4–A	B	do	do	174	⅞	248	8,980	2,738	Do.
Austin Red Diamond No. 5–A	B	do	do	179	1	267	6,760	2,061	Do.
Austin Red Diamond No. 6–A	B	do	do	175	⅞	218	10,380	3,165	Do.
Austin Red Diamond No. 1–G	C	4	do	226	1¼	280	10,950	3,338	Do.
Austin Red Diamond No. 2–G	C	do	do	170	1¼	302	11,380	3,470	Do.
Austin Red Diamond No. 3–G	C	do	do	174	1¼	325	8,710	2,656	Do.
Austin Red Diamond No. 6–G	C	do	do	175	⅞	345	7,490	2,285	Do.
Austin Red Diamond No. 1–D	B	1a	do	146	⅞	213	10,960	3,341	Do.
Big Red No. 1	B	do	do	171	⅞	240	7,250	2,209	The Equitable Powder Manufacturing Co., and the Egyptian Powder Co., East Alton, Ill.
Big Red No. 2	B	do	do	166	⅞	255	10,850	3,309	Do.
Big Red No. 6, L. F	B	do	do	174	⅞	242	7,480	2,280	Do.
Big Red No. 7	A	do	do	186	⅞	227	10,000	3,050	Do.
Bituminite 1	C	4	do	187	1¼	318	12,800	3,901	Ætna Explosives Co. (Inc.), New York, N. Y.
Bituminite 4	C	do	do	178	1¼	301	7,540	2,298	Do.
Bituminite 5	A	1a	do	176	1¼	231	9,120	2,782	Do.
Bituminite 8, L. F	C	4	do	155	1¼	303	9,300	2,834	Do.
Black Diamond No. 2–A	C	do	do	190	1¼	281	12,600	3,842	Illinois Powder Manufacturing Co., St. Louis, Mo.
Black Diamond No. 3–A	C	do	do	156	1¼	294	11,160	3,402	Do.
Black Diamond No. 5	A	1a	do	180	1¼	288	6,020	1,835	Do.
Black Diamond No. 6, L. F	C	4	do	158	1¼	306	9,630	2,935	Do.

[a] 1½ by 8 inch cartridge.

Permissible explosives tested prior to June 1, 1921—Continued.

Brand.	Class designation basis.		When used with detonators, preferably electric detonators, of not less efficiency than—	Weight of 1¼ by 8 inch cartridge.	Smallest permissible diameter.	Unit deflective charge.	Rate of detonation in 1¼-inch diameter cartridges.		Manufacturer.
	Volume of poisonous gases.	Characteristic ingredient.							
1	2	3	4	5	6	7	8		9
				Grams.	*Inches.*	*Grams.*	*Feet per second.*	*Meters per second.*	
Black Diamond No. 7	A	1a	No. 6	183	1¼	214	10,730	3,270	Illinois Powder Manufacturing Co., St. Louis, Mo.
Cameron mine powder No. 1–A	A	do	do	156	1¼	227	10,950	3,339	Grasselli Powder Co., Cleveland, Ohio.
Carbonite No. 1	C	4	do	226	1¼	280	10,950	3,338	E. I. du Pont de Nemours & Co., Wilmington, Del.
Carbonite No. 2	C	do	do	170	1¼	302	11,380	3,470	Do.
Carbonite No. 3	C	do	do	174	1¼	325	8,710	2,656	Do.
Carbonite No. 5	C	do	do	175	⅞	304	10,140	3,092	Do.
Carbonite No. 6	C	do	do	175	⅞	345	7,490	2,285	Do.
Carbonite No. 7	C	4	do	150	⅞	334	7,450	2,270	Do.
Coalite A, L. F	A	1a	do	164	⅞	204	11,590	3,534	Atlas Powder Co., Wilmington, Del., and the Giant Powder Co. (Con.), Giant, Calif.
Coalite B, L. F	A	do	do	147	⅞	205	11,390	3,474	Do.
Coalite C, L. F	A	do	do	166	⅞	215	12,190	3,716	Do.
Coalite D, L. F	A	do	do	154	⅞	214	12,070	3,680	Do.
Coalite E, L. F	A	do	do	168	⅞	237	6,220	1,896	Do.
Coalite F, L. F	A	do	do	162	⅞	362	4,640	1,414	Do.
Coalite G, L. F	A	do	do	151	⅞	218	7,970	2,430	Do.
Coalite H, L. F	A	do	do	184	1	260	6,350	1,936	Do.
Coalite I, L. F	A	do	do	164	⅞	267	9,240	2,816	Do.
Coalite KN	B	5	do	158	1	220	12,120	3,696	Do.
Coalite Y	B	1a	do	164	⅞	235	10,300	3,141	Do.
Coalite No. 1	C	do	do	232	1¼	296	7,930	2,418	Do.
Coalite No. 2–D	B	do	do	233	1¼	310	8,430	2,571	Do.
Coalite No. 2–M, L. F	C	do	do	157	1¼	301	9,220	2,811	Do.
Coalite No. 4–L. F	B	do	do	150	⅞	307	7,810	2,382	Do.
Coal special 1–A	C	do	do	148	1¼	276	9,370	2,857	Ætna Explosives Co. (Inc.), New York, N. Y.
Coal special 1, L. F	C	do	do	150	1¼	277	8,280	2,524	Do.
Coal special 2–W	C	do	do	180	1¼	277	11,590	3,534	Do.
Coal special 3–C	C	do	do	192	1¼	288	9,760	2,977	Do.
Collier A	A	1a	do	160	⅞	215	11,280	3,440	Do.
Collier B	B	do	do	156	⅞	207	10,970	3,345	Do.

Collier KN	A	do	do	175	1[illegible]	222	11,610	3,539	Do.
Collier Y	A	do	do	172	1[illegible]	229	9,740	2,970	Do.
Collier X, I. F. 1	B	do	do	164	[illegible]	237	8,140	2,483	Do.
Collier, X I. F. 2	A	do	do	165	[illegible]	228	9,950	3,035	Do.
Collier 5	A	do	do	178	1[illegible]	240	8,280	2,524	Do.
Collier 5, special	A	do	do	180	1[illegible]	236	8,330	2,541	Do.
Collier 6	A	do	do	169	[illegible]	214	11,220	3,422	Do.
Collier 11	A	do	do	165	[illegible]	217	11,680	3,561	Do.
Collier 11, L. F	B	do	do	180	1[illegible]	226	10,850	3,307	Do.
Cronite No. 1	A	do	do	149	1[illegible]	233	10,490	3,198	G. R. McAbee Powder & Oil Co., Pittsburgh, Pa.
Duobel	B	do	do	146	[illegible]	213	10,960	3,341	E. I. du Pont de Nemours & Co., Wilmington, Del.
Duobel No. 2	B	do	do	146	[illegible]	217	11,160	3,401	Do.
Du Pont Permissible No. 1	B	do	do	175	[illegible]	278	9,610	2,930	Do.
Franklinite 1	C	4	do	192	1[illegible]	288	9,760	2,977	Ætna Explosives Co. (Inc.), New York, N. Y.
Franklinite 4	B	do	do	198	1[illegible]	344	7,010	2,138	Do.
General A	C	do	do	204	1[illegible]	274	13,500	4,116	General Explosives Co., Chicago, Ill.
General B	C	do	do	187	1[illegible]	299	10,640	3,244	Do.
General C	B	do	do	186	1[illegible]	304	10,460	3,190	Do.
General 1	A	1a	do	168	[illegible]	208	10,650	3,247	Do.
General 2	A	do	do	152	[illegible]	217	11,510	3,508	Do.
General 3	B	1a	No. 6	169	[illegible]	213	8,150	2,486	General Explosives Co., Chicago, Ill.
General 3-X	A	do	do	203	1[illegible]	230	8,950	2,730	Do.
General 4	A	do	do	170	[illegible]	227	10,920	3,330	Do.
General 4-X	A	do	do	162	[illegible]	224	10,760	3,280	Do.
General 5	A	do	do	194	1[illegible]	220	10,510	3,204	Do.
General 5-X	A	do	do	172	1	274	6,600	2,013	Do.
General 6	B	do	do	154	7/8	221	12,050	3,674	Do.
General 6-X	A	do	do	194	1[illegible]	220	10,510	3,204	Do.
Grasselli A	B	4	do	183	1[illegible]	296	11,290	3,443	Grasselli Powder Co., Cleveland, Ohio.
Grasselli B	C	do	do	168	1[illegible]	340	9,540	2,908	Do.
Grasselli No. 1	A	1a	do	156	1[illegible]	227	10,950	3,339	Do.
Grasselli No. 5	A	do	do	161	1[illegible]	241	8,720	2,658	Do.
Grasselli No. 6	B	do	do	169	1[illegible]	224	8,090	2,467	Do.
Lomite No. 1	B	2	do	176	1[illegible]	300	13,940	4,250	G. R. McAbee Powder & Oil Co., Pittsburgh, Pa.
McAbee X	A	1a	do	156	1[illegible]	217	10,500	3,200	Do.
McAbee Y	B	do	do	149	1[illegible]	228	10,850	3,307	Do.
McAbee Z	A	do	do	151	1[illegible]	212	10,610	3,234	Do.
Mine-ite A	B	4	do	183	1[illegible]	296	11,290	3,443	Grasselli Powder Co., Cleveland, Ohio.
Mine-ite B	C	do	do	168	1[illegible]	340	9,540	2,908	Do.
Mine-ite No. 5-D	A	1a	do	161	1[illegible]	241	8,720	2,658	Do.
Mine-ite No. 6-D	B	do	do	169	1[illegible]	224	8,090	2,467	Do.
Miners Friend No. 1	B	do	do	167	[illegible]	223	11,580	3,529	Atlas Powder Co., Wilmington, Del.
Miners Friend No. 2	B	do	do	166	[illegible]	242	10,330	3,149	Do.
Miners Friend No. 3	B	do	do	167	[illegible]	242	8,030	2,449	Do.
Miners Friend No. 4	B	do	do	166	[illegible]	249	9,980	3,044	Do.
Miners Friend No. 5	B	do	do	166	[illegible]	250	8,570	2,614	Do.
Miners Friend No. 6	B	do	do	166	[illegible]	224	10,900	3,324	Do.
Miners Friend No. 7	A	do	do	176	[illegible]	253	8,950	2,729	Do.
Monobel Y	B	do	do	168	[illegible]	232	9,300	2,835	E. I. du Pont de Nemours & Co., Wilmington, Del.
Monobel No. 1	B	do	do	179	1[illegible]	216	11,700	3,568	Do.
Monobel No. 2	B	do	do	178	[illegible]	239	9,870	3,009	Do.

Peamissible explosives tested prior to June 1, 1921—Continued.

Brand.	Class designation basis.		When used with detonators, preferably electric detonators, of not less efficiency than—	Weight of 1¼ by 8 inch cartridge.	Smallest permissible diameter.	Unit deflective charge.	Rate of detonation in 1¼-inch diameter cartridges.		Manufacturer.
	Volume of poisonous gases.	Characteristic ingredient.							
1	2	3	4	5	6	7	8		9
				Grams.	*Inches.*	*Grams.*	*Feet per second.*	*Meters per second.*	
Monobel No. 3	B	1a	No. 6	174	⅞	243	7,260	2,212	E. I. du Pont de Nemours & Co., Wilmington, Del.
Monobel No. 4	B	do	do	174	⅞	248	8,980	2,738	Do.
Monobel No. 5	B	do	do	179	1	267	6,760	2,061	Do.
Monobel No. 6	B	do	do	175	⅞	218	10,380	3,165	Do.
Monobel No. 7	B	do	do	180	⅞	211	10,050	3,065	Do.
Nitro low-flame No. 1	C	4	do	234	1¼	303	13,380	4,079	Nitro Powder Co., Kingston, N. Y.
Nitro low-flame No. 2	C	do	do	226	1¼	298	14,560	4,439	Do.
Red H No. 1	B	1a	do	167	1¼	216	11,700	3,568	Hercules Powder Co., Wilmington, Del.
Red H No. 2	B	do	do	160	⅞	239	9,870	3,009	Do.
Red H No. 3	B	do	do	173	⅞	243	7,260	2,212	Do.
Red H No. 4	B	do	do	164	⅞	248	8,980	2,738	Do.
Red H No. 5	B	do	do	170	1	267	6,760	2,061	Do.
Red H No. 6	B	do	do	162	⅞	218	10,380	3,165	Do.
Red H No. 7	B	do	do	180	⅞	211	10,050	3,065	Do.
Red H No. 11	B	do	do	151	⅞	210	11,090	3,381	Do.
Red H No. 14	B	do	do	151	⅞	236	10,470	3,192	Do.
Trojan coal powder I	A	3	do	218	1¼	410	9,620	2,934	Pennsylvania Trojan Powder Co., Allentown, Pa.
Trojan coal powder J	A	do	do	229	1¼	360	10,590	3,230	Do.
Trojan coal powder L	B	do	do	166	1⅛	275	10,560	3,221	Do.
Trojan coal powder M-1	A	do	do	188	1	232	10,590	3,228	Do.
Trojan coal powder M-2	A	do	do	178	1	232	10,650	3,248	Do.
Trojan coal powder M-3	A	do	do	184	1	229	12,010	3,663	Do.
Trojan coal powder M-4	A	do	do	180	1	212	12,280	3,745	Do.
Trojan granular coal powder No. 1	A	do	do	[a] 247	1⅞	265	[b] 7,920	[b] 2,416	Do.
Tunnelite AA	A	1a	do	176	1⅛	253	7,690	2,346	G. R. McAbee Powder & Oil Co., Pittsburgh, Pa.
Tunnelite B	B	do	do	167	1⅛	249	9,990	3,047	Do.
Tunnelite C	A	do	do	187	1⅛	255	10,060	3,068	Do.
Tunnelite No. 3	C	4	do	150	1⅛	291	10,110	3,083	Do.
Tunnelite No. 4	C	do	do	136	1⅛	309	10,620	3,238	Do.

Tunnelite No. 6	C	do	do	172	1¼	305	9,670	2,947	Do.
Tunnelite No. 8	C	do	do	158	1¼	324	8,020	2,446	Do.
Tunnelite No. 8, L. F	C	do	do	176	1¼	322	8,720	2,658	Do.
Union A, L. F	B	1a	do	165	1⅛	214	11,670	3,557	Union Explosives Co., Clarksburg, W. Va.
Union B, L. F	B	do	do	162	1⅛	248	10,260	3,128	Do.
Union C, L. F	B	do	do	169	1⅛	254	10,330	3,149	Do.
Union No. 1	C	4	do	183	1⅛	279	11,640	3,548	Do.
Vigorite No. 1	C	do	do	204	1¼	252	10,950	3,338	Atlas Powder Co., Wilmington, Del., and the Giant Powder Co. (Con.), Giant, Calif.
Vigorite No. 5	C	do	do	165	⅞	304	10,830	3,303	Do.
Vigorite No. 6	C	do	do	166	⅞	345	7,490	2,285	Do.
Vulcan Coal Powder No. 1	C	do	do	[c] 182	1⅜	335	[d] 7,720	[d] 2,354	Puget Sound & Alaska Powder Co., Everett, Wash.
Vulcan Coal Powder No. 2	B	do	do	[c] 193	1	283	[d] 10,680	[d] 3,257	Do.
Xpdite No. 1	C	do	do	211	1¼	259	10,950	3,338	Hercules Powder Co., Wilmington, Del.
Xpdite No. 2	C	do	do	168	1¼	302	11,380	3,470	Do.
Xpdite No. 3	C	do	do	162	1¼	325	8,710	2,656	Do.
Xpdite No. 6	C	do	do	165	⅞	345	7,490	2,285	Do.

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[a] 1⅞ by 8 inch cartridge.
[b] 1⅛-inch diameter cartridge.
[c] 1⅛-inch diameter cartridge.
[d] Rate of detonation made in 1¼-inch diameter cartridge.

CLASSES OF PERMISSIBLE EXPLOSIVES.

In order that the user of explosives may be able the better to select an explosive to meet a specific requirement the Bureau of Mines now classifies permissible explosives in two ways, as follows: (1) On the basis of the volume of poisonous gases produced by 1½ pounds (680 grams) of the explosive, and (2) on the basis of the characteristic ingredient of each explosive.

VOLUME OF POISONOUS GASES.

Most of the permissible explosives even when properly and completely detonated in a drill hole in a coal mine produce poisonous gases, but they produce at the same time a much larger volume of nonpoisonous gases. In order that the poisonous gases may not under normal conditions become a menace to the lives or health of miners no explosive is now or can become permissible if it evolves upon detonation more than 158 liters (5½ cubic feet) of permanent poisonous gases, as determined by test in the Bichel pressure gage. Field tests of an explosive made under extreme conditions for the production of the greatest percentage of poisonous gases in the air show that in a narrow entry, with no ventilation at or near the face, a 1½-pound charge of an explosive, which gave 158 liters of poisonous gas in gage tests, produced 0.18 per cent of carbon monoxide (the only poisonous gas present) in the air when the sample was taken two minutes after the shot. Another sample of the air taken two minutes later contained 0.08 per cent of carbon monoxide. It is therefore evident that where ventilation is not active, as in a closed heading, miners or shot firers should not return to the face until at least five minutes after a shot. At all working faces that are difficult to ventilate explosives of class A or class B should be used, preferably those of class A.

The classification on the basis of the volume of poisonous gases produced by 1½ pounds (680 grams) of the explosive is as follows:

Class A, those explosives from which the volume of poisonous gases produced is not more than 53 liters.

Class B, those explosives from which the volume of poisonous gases is more than 53 liters but less than 106 liters, inclusive.

Class C, those explosives in which the volume of poisonous gases is more than 106 liters but less than 158 liters, inclusive.

CHARACTERISTIC INGREDIENTS.

Explosives are classified in accordance with their characteristic ingredient as follows:

Class 1, ammonium nitrate explosives.—To class 1 belong all the explosives in which the characteristic ingredient is ammonium nitrate. This class is divided into two subclasses. Subclass A includes every ammonium nitrate explosive that contains a sensitizer that is in itself an explosive. Subclass B includes every ammonium nitrate explosive that contains a sensitizer that is not in itself an explosive. The ammonium nitrate explosives of subclass A consist principally of ammonium nitrate with small percentages of nitroglycerin, nitrocellulose, or nitrosubstitution compounds which are used as sensitizers. The ammonium nitrate explosives of subclass B consist principally of ammonium nitrate with small percentages of resinous matter or other nonexplosive substances used as sensitizers.

Ammonium nitrate explosives, when fresh and properly detonated, are well adapted for use in mines that are not unusually wet. They are not suitable for use in wet mines, for if the contents of a cartridge of ammonium nitrate explosive is exposed for only a few hours to the damp atmosphere the explosive may so deteriorate as to fail to detonate completely, because ammonium nitrate takes up moisture readily. The redipping of cartridges of ammonium nitrate explosives aids in protecting the contents against moisture, or moist air, and the cartridges should be so stored and handled as to preserve the efficacy of the paraffin-like coating. The explosives should be obtained in a fresh condition and purchased in such quantities as will permit their prompt use. Experience at the Pittsburgh experiment station of the bureau shows that ammonium nitrate explosives will usually detonate completely after storage for six months in a well-ventilated magazine.

Class 2, hydrated explosives.—To class 2 belong all explosives in which salts containing water of crystallization are the characteristic ingredients. The explosives of this class are somewhat similar in composition to the ordinary low-grade dynamites, except that one or more salts containing water of crystallization are added to reduce the flame temperature. They are easily detonated, and most of them can be used successfully in damp working places.

Class 3, organic nitrate explosives.—To class 3 belong all the explosives in which the characteristic ingredient is an organic nitrate other than nitroglycerin. The permissible explosives now listed under class 3 are nitrostarch explosives.

Class 4, nitroglycerin explosives.—To class 4 belong all the explosives in which the characteristic ingredient is nitroglycerin. These explosives contain free water or an excess of carbon, which is added to reduce the flame temperature. A few explosives of this class contain salts, or an unusually low percentage of nitroglycerin, that reduce the strength and shattering effect of the explosives on detonation. The nitroglycerin explosives have the advantages of detonating easily and of not being readily affected by moisture.

Class 5, ammonium perchlorate explosives.—To class 5 belong all explosives in which the characteristic ingredient is ammonium perchlorate. This is a new classification by the bureau.

WEIGHT OF 1¼ BY 8 INCH CARTRIDGE.

The size in which cartridges of permissible explosives are usually sold is 1¼ by 8 inches, and from the weight of a cartridge of this size as given in the table the number of cartridges required to make the 680 grams (1½ pounds) maximum permissible quantity of explosive in a shot may be readily determined. To illustrate, the first explosive on the accompanying list (Aetna coal powder A), like all the other explosives on the list, is permissible only when fired in charges not exceeding 680 grams (1½ pounds). The maximum permissible weight shot (680 grams), divided by the weight of one 1¼ by 8 inch cartridge (184 grams of Aetna coal powder A), gives the maximum permissible number of cartridges of this size that may be used, 3⅝ (or 3.69) cartridges.

SMALLEST PERMISSIBLE DIAMETER.

In order that the user may know readily the smallest diameter in which a given explosive is permissible, this information is given in the table. Should a manufacturer desire that an explosive be approved as permissible in a smaller diameter than that in which it is now permissible, he should make application for the necessary tests.

UNIT DEFLECTIVE CHARGE.

The unit deflective charge is that weight of an explosive in grams which gives the same swing on the ballistic pendulum as 227 grams (½ pound) of Pittsburgh Testing Station Standard 40 per cent straight nitroglycerin dynamite.

The bureau requires that this unit deflective charge shall not exceed 454 grams (1 pound), as tests have shown that explosives whose unit deflective charge exceeds 454 grams (1 pound) require more than 680 grams (1½ pounds), in a single charge to satisfactorily blast down coal and when so used are not permissible.

Many observers have expressed the opinion that the "coal-getting" strength of permissible explosives is represented better by the results of this test than by the results of any other single test yet devised. The reader should note that the results do not take into consideration whether the coal when shot down is fine or coarse.

In comparing the percentage strength of one explosive with that of another explosive a fine distinction should not be drawn, for it must be remembered that tolerance limits have been established for the results with the ballistic pendulum, as given on page 41, and these limits are designed to cover all reasonable variations of manufacture, sampling, and chemical and physical determinations made. This principle applies to all the items of the chemical analysis as well as to the items of the physical tests.

RATE OF DETONATION.

The table shows in feet per second and meters per second the relative velocity of detonation of each explosive. The adaptability of a permissible explosive to a particular coal-mining condition depends greatly on its rate of detonation. For certain work in which a shattering effect is desired, as in driving through or "brushing" rock, or in producing coal for coke making, the explosive reaction should be rapid, and for such work permissible explosives having a high rate of detonation should be selected. Similarly, for shooting down a soft, friable coal to produce lump or steam coal, a permissible explosive should be selected that detonates slowly and hence gives a more prolonged pressure. In medium hard coal an explosive having an intermediate rate of detonation may be expected to be most suitable.

Although these relations usually hold, they do not always, because coals differ in hardness and coal beds differ in the number and position of the joints, partings, and shale bands. Such facts have to be considered in selecting an explosive for mining coal.

An explosive having a very low rate of detonation is not always the best for mining a friable coal much fractured, because some of its energy may be lost by its gases escaping through the fractures. Under such conditions an explosive having an intermediate rate produces the most economical results.

TOLERANCES FOR PERMISSIBLE EXPLOSIVES.

The tolerances promulgated by the Bureau of Mines provide for reasonable limits of variation in the results of analyses and tests of field samples and manufacturers' samples of permissible explosives. These tolerances as now existing and as stated below are quoted, except as amended November 15, 1920, and February 26, 1921, from Bulletin 96, in which they were first published after having been established and made effective July 1, 1915.

In order to define more exactly what is meant by the phrase "similar in all respects" in the definition of a permissible explosive—namely, "A permissible explosive is an explosive which is similar in all respects to the sample which has passed certain tests prescribed by the Bureau of Mines to determine its safety for use in gaseous and dusty coal mines, and when used in accordance with the conditions prescribed by the bureau"—the following tolerances are established for field samples or manufacturers' samples of explosives, beyond which such lot of explosives can not vary and still be considered permissible for use in coal mines.

Chemical analysis.—Moisture, to be fixed by a sliding scale from 1½ per cent at zero to 4 per cent at 10 per cent of moisture in original sample, this tolerance being on total percentage of moisture in the explosive.

Other ingredients (or their equivalents) in quantities not exceeding 60 per cent, according to curve shown in figure 1, except that the chemical tolerance for carbonaceous combustible material is changed to plus or minus 3 per cent regardless of the amount of carbonaceous combustible material reported as present. For ingredients in quantities of 60 per cent or more, the tolerance shall be plus or minus 3 per cent: *Provided*, That the ingredients of a permissible explosive shall be considered to be those substances reported as found by the Bureau of Mines in the original sample of that explosive submitted for test as to its permissibility: *And provided further*, That an equivalent shall be considered to be a substance which would not materially alter the properties of the explosive and which would produce the same result as the original substance.

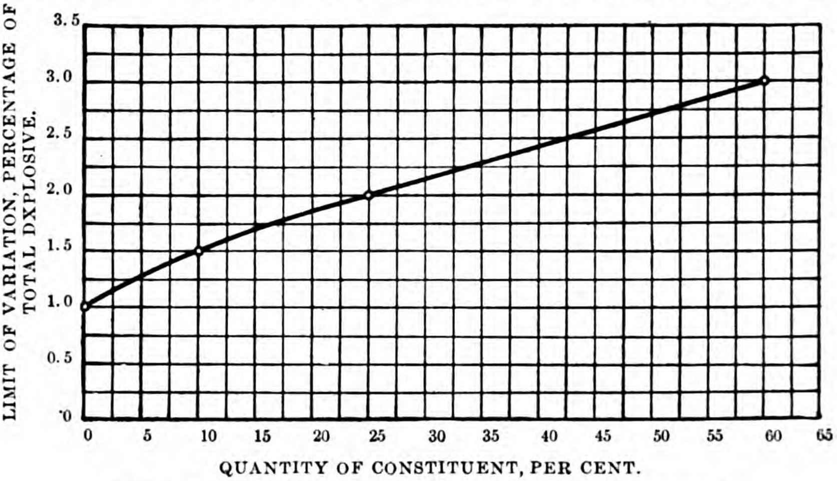

FIGURE 4.—Curve of limit variation in composition of permissible explosives.

For the purpose of applying the chemical tolerance for explosives containing ammonium nitrate, the commercial ammonium nitrate will be reported as the sum of the ammonium nitrate, the ammonium chloride and ammonium sulphate reported as present, and the tolerance applied to this figure. The sum of the ammonium chloride and the ammonium sulphate will be reported separately in a note and the tolerance applied to their sum will be 4 per cent of the commercial ammonium nitrate reported as present in the basic sample, except in those cases where the tolerance thus applied would be less than for a separate ingredient, when the tolerances for "other ingredients" would apply.

Products of combustion (*determined by Bichel gage tests*).—The volume of poisonous gases from 680 grams of the explosive, including its wrapper, must be less than 158 liters, except that in case the first test yields 158 liters or more poisonous gases per 680 grams of the explosive, including its wrapper, the average result of three tests agreeing within 5 per cent of each other shall be taken, and no explosive shall remain permissible when this average for poisonous gases exceeds the above standard limits.

Physical tests.[5]—In making rate of detonation and unit deflective charge by the ballistic pendulum, the tests stop after obtaining three results within 5 per cent, or a total of six results. All the results within 10 per cent will be averaged. If there are two or more groups in which the results are within 10 per cent of each other, then all the results which are within any group will be averaged.

The tolerances applied using the above rules are:

Rate of detonation (the average of 3 to 6 trials within 10 per cent with Mettegang Recorder) plus or minus 15 per cent.

Unit deflective charge determined by the ballistic pendulum as compared with the Pittsburgh Testing Station standard 40 per cent straight nitroglycerin dynamite (the average of 3 to 6 trials within 10 per cent with the ballistic pendulum), plus or minus 10 per cent.

Grams of wrapper per 100 grams of explosive, plus or minus 2.0 grams (average of four determinations): *Provided*, That the manufacturers shall submit samples of all different sizes of cartridges, to be considered as part of the original sample, the amount of wrapper to be determined for each size of sample: *And provided further*, That the tolerances as suggested shall be determined in comparison with the various diameters of samples as submitted with the original sample.

Apparent specific gravity of cartridge, by sand, plus or minus 7.5 per cent (average of four determinations): *Provided*, That actual density shall be determined on cartridges of the same diameter as the standard: *And provided further*, That manufacturers shall be required to submit samples of all sizes.

Gas and dust gallery No. 1.—No ignition must be obtained in each of one or more trials. Note: In the retesting of permissible explosives by tests 1 and 4, the charges of the explosives fired will be reduced 10 per cent in weight from the weights originally used in order to eliminate any likelihood of a failure being due to the natural variations in the gallery conditions.

Pendulum friction test.—Each explosive must pass a test of 10 trials under the same conditions as originally tested, except that the height of fall of the wood-fiber shoe will be reduced by 10 per cent in order to eliminate any likelihood of a failure being due to the natural variations in test conditions.

FIELD SAMPLES OF PERMISSIBLE EXPLOSIVES.

The bureau will from time to time reexamine permissible explosives found in commercial shipments and in the field to determine how closely they conform to the samples upon which the permissibility tests were originally made, and the manufacturer will be notified of the results of tests on all field samples. In order that this examination can be properly made, the tolerances as given above are applied in the manner stated below, according to the rules and regulations promulgated November 15, 1920, and February 26, 1921. These methods of applying the tolerances supersede all previous methods.

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[5] For method of making these tests, see Howell, S. P., and Tiffany, J. E., Methods for routine work in the explosives physical laboratory of the Bureau of Mines: Tech. Paper 186, Bureau of Mines, 1918, 63 pp.

In the event that a field sample of a permissible explosive exceeds the tolerance for one or more items, the bureau will take the following action:

(*a*) If the explosive exceeds the tolerance for any items of the chemical analysis, for grams of wrapper per 100 grams of explosive, for apparent specific gravity, for rate of detonation, or for unit deflective charge, the manufacturer only will be advised of the results, except that, should these results in the opinion of the explosives engineer indicate that the explosive is unsafe for use, then the operator or owner will be immediately warned, and further tests promptly inaugurated.

(*b*) If the explosive exceeds the tolerance for gallery tests, pendulum friction test, or poisonous gases, the bureau will declare that particular lot of explosive not permissible, and a copy of the notification to the consumer or owner will be furnished the manufacturer, the notification to state that the explosive did not meet the requirement for gallery tests, pendulum friction test, or poisonous gases, as the case may be.

The term "Lot of permissible explosives" as used in the tolerances promulgated by the director, is defined as "all of that explosive in the magazine from which the sample is procured, bearing identical case markings."

When a given lot of explosive is declared not permissible and the owner and the manufacturer notified, the bureau does not attempt to fix responsibilities between owner and manufacturer.

The usual causes of an explosive exceeding the tolerances for chemical analysis or physical tests are two: (1) It may not have been properly manufactured; (2) it may not have been properly stored. The manufacturer is responsible for (1) because the consumer has no control over the method of manufacture of the explosive, but the consumer or owner is responsible for (2) because the manufacturer has no control over the conditions of storage when the explosive has once passed from his ownership.

The manufacturer should exercise due care that the quality of the raw materials, and the weighing and incorporating of them, is similar in all respects to that for the original sample of explosives submitted for tests; and that the explosive is fresh and in first-class condition when sold. The user should store explosives in well-ventilated magazines, at temperatures not exceeding 90° F. The boxes should be placed so that the cartridges lie horizontally, though the tops of the boxes may be up or down. The explosives purchased first should be used first, and hence older explosives should not be stored under or behind a fresh consignment. It is well to purchase explosives in such quantities that they can be used promptly.

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